Seminar Report

On

A Fuzzy-Timestamp based Adaptive Gateway Discovery Protocol in Integrated Internet-MANET

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Shivanshu Upadhyay

Abstract

In MANET, nodes are able to communicate with each other for a short range only. To extend the communication range of MANET, an Internet gateway is used which acts as a bridge between the conventional network and MANET. To enable the long range communication, a MANET node needs to discover and then select the appropriate gateway using various proposed schemes. Some of the schemes suffer from lack of efficient gateway discovery mechanism. They use a single Hop count metric to select gateway which can be a bottleneck in the network. This paper aims at providing a simple and an efficient adaptive gateway discovery and selection mechanism using fuzzy logic to combine two metrics Hop Count and Latency which leads to selection of a less congested as well as short path.

Content

1. Introduction

In MANET, nodes are able to communicate with each other for a short range only. To extend the communication range of MANET, an Internet gateway is used which acts as a bridge between the conventional network and MANET. To enable the long range communication, a MANET node needs to discover and then select the appropriate gateway using various proposed schemes. Some of the schemes suffer from lack of efficient gateway discovery mechanism. They use a single Hop count metric to select gateway which can be a bottleneck in the network. This paper aims at providing a simple and an efficient adaptive gateway discovery and selection mechanism using fuzzy logic to combine two metrics Hop Count and Latency which leads to selection of a less congested as well as short path. negative side is that there is more overhead due to continuous periodic advertisements messages by the gateway. In reactive approach, communication is initiated by the MANET nodes by sending GW_SOL messages to gateway. It is on-demand gateway discovery approach where gateway replies to R_REQ. The positive side of this approach is that there is less overhead than proactive but the negative side of it is that there is more end to end delay since route discovery is initiated when Internet connection is needed by the node.

The Gateway carries out two main tasks. Firstly, it provides the ad hoc routing capabilities that are absent in conventional Access Routers so that the downlink traffic can be conveniently re-routed into the MANET. Secondly, the Gateway broadcasts Modified Router Advertisement (MRA) messages, which contain similar information to Router Advertisement messages of the Access Router but which can be propagated in the MANET. As these messages are received by all the nodes in the MANET, they can configure their own IPv6 addresses to be globally reachable by any terminal in the Internet.

The Gateway Discovery process may be classified into three main categories: proactive, reactive and hybrid. Reactive protocols only find a route to the Internet Gateway (IGW) when the nodes send data. In the proactive algorithms, the Internet Gateway periodically send MRA messages; and, finally, hybrid schemes use a mix of both proactive and reactive discovery schemes.

In hybrid approach, both the previous strategies are used to discover gateway. Some part of network works proactively whereas the remainder of it works reactively. Mobile nodes which are beyond the range of proactive zone discover gateway reactively. The positive side of this approach is that it overcomes the disadvantages of both the previous approaches but it also increases the complexity of gateway discovery and selection mechanism.

In traditional hybrid approach, the proactive area is set statically and never changed. This leads to a very rigid approach wherein the current network conditions are not taken into consideration for adjusting the proactive region i.e. TTL dynamically. Another issue is the setting of GW_ADV periodically.

Figure 1 depicts architecture of a MANET network interconnected with Internet using gateways. In this figure nodes within two hop range are using proactive scheme to connect with gateway and the remaining nodes are using reactive scheme.

In the paper, thus proposed an adaptive gateway discovery mechanism using a modified version of MAXIMAL SOURCE COVERAGE. It aims at providing a simple and an efficient adaptive gateway discovery and selection mechanism.

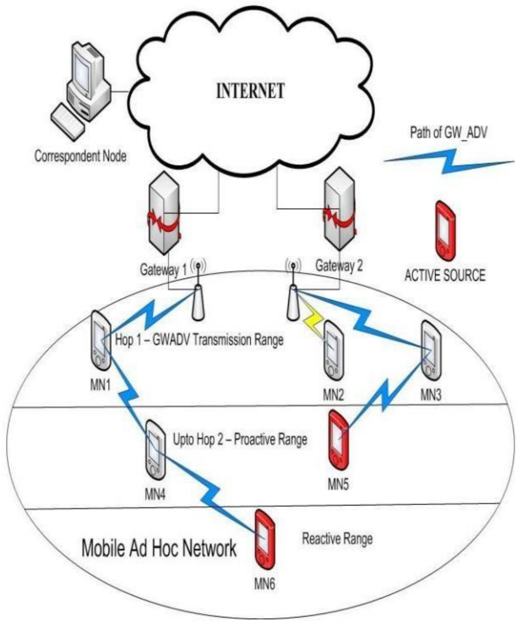

Figure 1. MANET Internet Architecture

2. Motivation

MANET has a dynamic nature, which makes it ideal for different applications. This kind of network is more suitable in emergencies such as natural disasters due to quick deployment and minimal configuration. MANET is becoming more popular in the advance technology deployment devices such as mobile phones, Wi-Fi capable laptops etc.

Routing in ad-hoc networks has been a challenging task ever since the wireless networks came into existence. The major reason for this is the nature of ad-hoc networks where network topologies cannot be static. The conceptual framework of routing involves decision as to what appropriate optimal routing paths should be taken for transferring the data (packets) through an internetwork. The first concept, i.e. determining an optimal path, is a very complex activity while the later one, i.e. forwarding data through selected path, is a straight forward activity.

In order to exchange information between different nodes, routing needs to be done by using different routing protocols. Therefore efficient routing protocols are key components of successful, reliable and proficient communications. Efficient routing protocol means that an optimal route selection is done by the protocol in different scenarios to improve the overall network performance.

Thus there is a need to develop an efficient and effective Dynamic Routing Protocol which can be used to reduce or minimize the problems like Latency, Optimal Path, High Bandwidth consumption and better network utilisation and in order to suffice the needs of the various real world applications of Integrated MANET .

3. Related Works

Various adaptive gateway discovery mechanism exist which dynamically adjust the advertisement zone. Ruiz et. al. [1] proposed dynamic adjustment of proactive zone is made by adjusting the TTL value using maximal source coverage algorithm. TTL value of the GW_ADV messages is adjusted depending on network conditions. Higher the TTL value higher the proactiveness of the approach. In reactive gateway discovery scheme a mobile node depends only on the single reply which is unicasted from the gateway as a response to the gateway discovery request message and mobile node has to initiate a new gateway discovery request message if the only reply sent by the gateway is missed. Ruiz et. al. [2] discussed about the maximal benefit coverage strategy. This strategy adjusts the TTL value of GW_ADV messages dynamically. Maximal benefit coverage is introduced in which gateways set the TTL value of their GW_ADV messages dynamically which gives maximal benefit. Maximal benefit can be calculated.

Zhang et al. [3] dynamically adjusts the TTL value of the GW_ADV messages and also the advertisement interval according to the change in topology and the node mobility.

Bin et al. [4] also discusses strategy in which complete adaptive is proposed. GW_ADV messages are sent periodically at large intervals and the periodicity is adapted with mobility detection in the MANET. For dynamism in TTL value of the GW_ADV message maximal benefit coverage algorithm is used. To decide whether to adapt TTL periodicity, a heuristic function is used. At regular intervals, each gateway calculates its regulated mobility degree (RMD), which estimates the amount of mobility of the source nodes which has registration with the gateway. The RMD parameter is used as a threshold value to determine whether to bring adaptation to the periodicity of the GW_ADV message. If there is a requirement of adaptation, it is done according to the maximal benefit coverage algorithm.

Hamidian et al. [5] proposed a solution, which provides Internet connectivity to ad hoc networks by modifying the AODV routing protocol. His approach is based only on the number of physical hops to gateway as the metric for the gateway selection.

4. Proposed Work

In Pedro et al. [1] maximal source coverage algorithm is used for dynamism in proactive zone by adjusting TTL value dynamically. It is one of the simplest and the first adaptive scheme proposed for dynamic adjustment of TTL value periodically. The algorithm sends the next GW_ADV with TTL value equal to the maximum number of hops for all the active sources that are communicating with the Internet either proactively or reactively. The main advantage of using maximal source coverage algorithm is that it maintains a high packet delivery ratio with low overhead cost. And also it gives better scalability. But the drawback with this approach is that even if one source is located at a far distance from the gateway the proactive zone would have to be increased to cover that node which will lead to more than tolerable overhead. Our proposed approach extends the approach given in Pedro M Ruiz et al. [1] by using modified version of maximal source coverage for the dynamic adjustment of TTL value which overcomes the above discussed drawback. We have introduced two new parameters N_p and N_r for our proposed approach. N_p is the number of active sources using gateway proactively. N_r is calculated from the mobile nodes that are using gateway reactively. The check used before broadcasting new GW_ADV ensures that the overhead due to periodic broadcasting of messages is minimized. Only when the number of reactive active sources requiring internet connectivity reaches a certain threshold compared to proactive active sources, the proactive zone is expanded. This is used to keep a tab on control overhead. Table 1 shows the modified Gateway advertisement message format

Table 1.Modified Gateway Advertisement Message Format (GW_ADV)

<table>
<tr><td>Type</td><td>Reserved</td><td>Prefix Size</td><td>Hop Count</td></tr>
<tr><td colspan="4" align="center">Broadcast ID</td></tr>
<tr><td colspan="4" align="center">Destination IP Address</td></tr>
<tr><td colspan="4" align="center">Destination Sequence Number</td></tr>
<tr><td colspan="4" align="center">Source IP Address</td></tr>
<tr><td colspan="4" align="center">TTL</td></tr>
<tr><td colspan="4" align="center">Timestamp</td></tr>
</table>

Table 2.Modified Routing Table Structure

Entry #	Destination Address	Next hop address	Number of physical hops	Store_ op_P_Value
1	Internet Node (0.0.1)	default(-10)	-1	-1
2	default(-10)	Gateway (1.0.1)	3	5
3	Gateway (1.0.1)	Mobile Node (1.0.3)	3	2

4.1 Gateway Selection Strategy

A mobile node must be able to select a gateway that is best suitable for its needs. To enable efficient gateway selection, various metrics are used .Few of such metrics are Hop Count, Remaining Energy, Path Load. In the paper a combination of hop count and timestamp to determine which gateway to use for Internet Connectivity. Timestamp field is added to the GW_ADV messages to make it a GW_ADV_NEW messages. This field contains the time at which the message was sent by the gateway. Table 1 shows the modified Gateway advertisement message format .Table 2 shows the new routing table format with the new field for Store_op_P_Value .This field is calculated by a fuzzy rule and used in selecting an optimum gateway.The symbols used in the algorithm are described in Table 3.

Table 3. Symbols used

Variables	Comments
N_p	Number of active sources in the proactive area
N_r	Number of active sources in the reactive area
$Hops_i$	Number of hops from the gateway for active source 'i'.
op_P_Value	Optimal path value used for gateway selection.

4.2 Algorithm

Step 1: Initialize, TTL=0, N_p=0 and N_r=0.

Step 2: //In each gateway advertisement cycle:

// Calculate N_r and N_p.

//N_r is estimated by gateway as follows:

For each R_REQ message that a gateway receives If (Broadcast ID is unique)

N_r++

Else

Discard R_REQ message.

// Estimate the new value of N_p :

For each active source using the gateway to connect to Internet

If (Hop Count <=TTL)

N_p++;

Step 3: Calculate TTL value to be used. if (N_r>=1/2N_p) Then

TTL=Average of the hop count in Reactive region

Step 4: (i) Timestamp=current time at gateway

(ii) Hop Count =0;

Broadcast GW_ADV with new TTL value, Timestamp.

Step 5: If a mobile node receives a duplicate Internet gateway advertisement, then drop it and exit.

Step 6: For each unique Internet gateway advertisement arrival Hop Count++

Step 7: //Check whether an advertisement is from the same Internet gateway

If (advertisement from the same Internet gateway) && (ad_dst_seqno > default_rt_seqno)

Then Latency=CurrentTime – Timestamp Latency and Hop Count are fuzzfied to calculated and optimal path value (op_P_Value).

If (op_P_Value >Store_op_P_Value)

Then update default_rt_sequence, Hop Count, Store_op_Value, Expiration Time etc in mobile routing table

Step 8: // Update routing table of mobile node

// hop_count refers a field in a mobile routing table

(i)Store_op_P_Value=op_P_Value
(ii)hop_count=Hop Count;
(iii)Also update route table next hop address towards this Gateway.

Step 9: // In case gateway advertisement is being received from a different gateway, make a hand off to another Internet gateway.

Else if (advertisement is not from the same Internet gateway) && (op_P_Value >Store_op_P_Value) then

Step 10: // Update the following entries in the mobile node

(i)Make new discovered Internet gateway as default gateway.

(ii)Also update default_rt_value, Store_op_Value, expiration time, hop count etc in the mobile node's routing table.

Step 11: Else keep on using current gateway as the default gateway.

Step 12: Repeat step 2

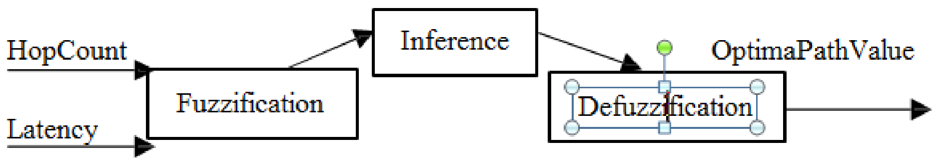

Figure 2. Fuzzification Process

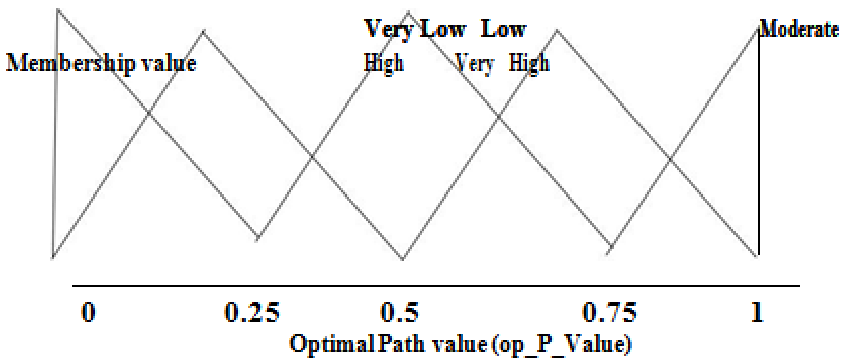

Figure 3. Membership function of the inputs for the fuzzy system

Figure 2 shows the general fuzzification process and Figure 3 gives the membership function and output of the System. To enable an efficient gateway selection scheme, fuzzification of the two important selection parameters hop count and latency. The routing table at each node stores the op_P_Value which is the defuzzified output. After receiving each GW_ADV message the mobile nodes use the output of the fuzzy logic which uses Hop Count and Latency and compare this output with stored value to decide which gateway to use. Table 4 describes the rules used in the fuzzy system is designed

Table 4. Fuzzy Logic Rule Base

Hop Count	Latency	PathSelection
Low	Low	Very high
Low	Moderate	High
Low	High	Moderate
Moderate	Low	High
Moderate	Moderate	Moderate
Moderate	High	Very low
High	Low	Moderate
High	Moderate	Low
High	High	Very low

4.3 Performance Metrics

To assess the effectiveness of the proposed gateway discovery mechanism, the following performance metrics are used:

Throughput: It is defined as the ratio of total number of data bits (i.e. packets) successfully received at the destination to the simulation time.

End-to-End Delay: It is defined as the delay for sending packets from source node to the fixed host. This metric includes all the possible delays caused by buffering during the Internet gateway discovery latency, route discovery latency, queuing at the interface queue, retransmission delays at the MAC layer, and propagation and transfer times.

It is examined the impact of traffic load in terms of two metrics: throughput and average end-to-end delay to evaluate our proposed protocol.

In Hamidian approach [5], the traffic rate of source node increases which leads to congestion across various mobile nodes due to minimum hop count metric used. Consequently, drop of packets starts occurring due to interface queue overflow. However, in our proposed approach as the mobile node chooses the gateway not just using hop count metric but also latency i.e. the time difference between current time at node and timestamp value send by the gateway in the new gateway advertisement messages, which results in the balancing of traffic load across the network.

The use of fuzzy logic has led to an optimal gateway selection scheme which has resulted in reduced average end to end delay compared to that in Hamidian [5] as shown in Figure 5. And also the Throughput of mobile node obtained at the destination is better than proactive gateway discovery (see Figure. 4) as our protocol balances the load uniformly by distributing traffic across different routes. In Hamidian [5], the packet drop occurrence is more due to shortest path chosen by most of the nodes but in our case mobile choses a route having lesser traffic.

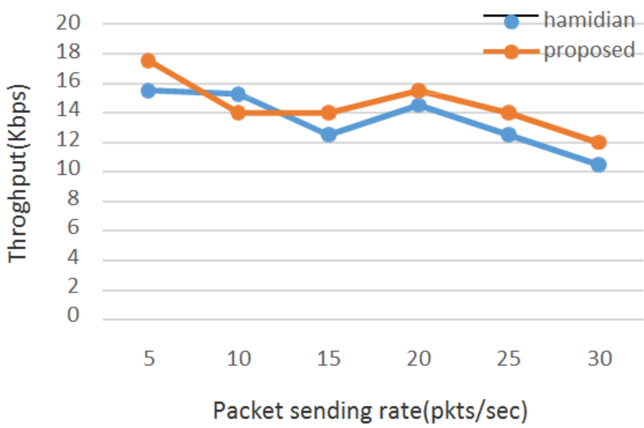

Figure 4. Throughput of a Mobile Node

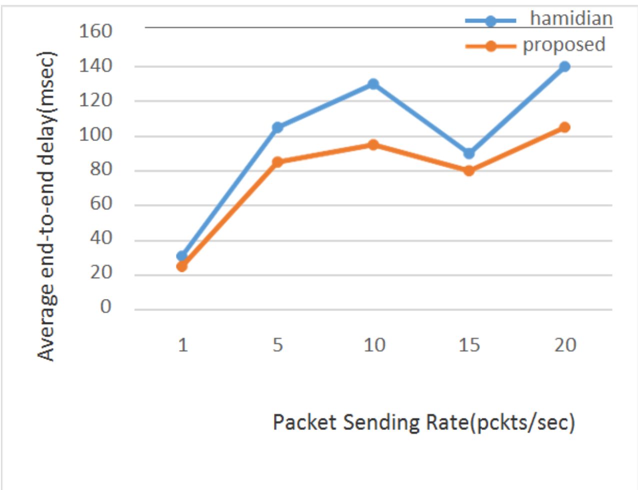

Figure 5. Average end to end delay of a Mobile Node

5. Conclusion

This Internet gateway discovery scheme is able to reduce the congestion across various nodes in Ad Hoc networks for Internet access. The algorithm is evaluated as proposed protocol performance through simulation in various traffic and mobility situations. Simulation results confirm the performance in terms of throughput and delay improvement of our scheme as the traffic load gets increased and the mobility as well. This proposed approach distributes the traffic evenly among all the mobile nodes in an Ad Hoc networks as traffic/mobility in MANET domain increases. The result is compared with an existing Hamidian [5] proactive route discovery scheme and support load balancing mechanisms. So, by the above results and discussion we can say that our approach outperforms the Hamidian [5] approach with increase in traffic load and mobility.

6. References

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