A Hybrid Gateway Discovery Method for Mobile Ad hoc Networks

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Abstract— Mobile Ad hoc Network (MANET) consists of a set of mobile nodes which communicate among them only using their wireless interface. In order to get connected with internet, mobile nodes need to find out Gateway (GW), a particular type of mobile nodes which are directly connected with internet. Proactive, reactive, and hybrid, are the three methods for gateway discovery. In hybrid approach, GW nodes maintain their proactive property only within a range of the MANET and GW nodes do not broadcast advertise message outside that range. Current hybrid approach uses a very small heuristic value for this range and therefore majority portion of the MANET still has to follow reactive approach. This paper proposes a novel hybrid method using an adaptive value for this range which ensures proper utilization of hybrid method. In this method, after receiving replies from several mobile nodes in response to initial advertisement message, the GW sets its range for next broadcast based on the mean distance of all mobile nodes those have replied. This variable range allows the GW to send advertise message to long distance and at the same time follows reactive property too. Experiments show that this proposed approach achieves better results in term of packet delivery rate, delay, and packet drop.

Keywords-Gateway advertisement message; advertisement interval; advertisement zone; TTL

I. INTRODUCTION

A mobile ad hoc network (MANET) is a network of mobile nodes (MNs) which is formed and functioning without any established infrastructure or centralized administration. These mobile nodes use a wireless interface to communicate with each other and move at the same time. Moreover, these mobile nodes serve as both hosts and routers so that they can forward packets on behalf of each other. Hence, the mobile nodes are able to communicate beyond their transmission range by supporting multi-hop communication. In a MANET mobile nodes only can communicate within the ad hoc boundary. MANETs are advantageous because they are easy to deploy and self-configurable.

A most developed and implemented reactive MANET routing protocol is Ad hoc On-Demand Distance Vector (AODV) [1]. Each node in MANET, following AODV, maintains a routing table which contains route entry about destination currently communicating with. Particularly, the route entry table contains a number of fields like Destination IP Address, Hop Count (the number of hops needed to reach the destination), Next Hop (a neighbor node chosen to forward packets to the destination) and Lifetime (the expiration or deletion time of the route). Handover (a mobile node decides which gateway to use that is closer in terms of number of hops). When a mobile node receives gateway advertisements from more than one gateway, it has to decide which gateway is best to use to connect with Internet. Thus a mobile node begins a handover when it receives an advertisement from a gateway that is closer [5] rather than the one it is currently registered with.

Shortest hop count is the number of intermediate hops from the node to the gateway. It is important for choosing the best and shortest path between source and destination nodes. Load-balancing is used for MANET nodes within the same MANET domain to send intra MANET traffic to choose different Internet Gateways (IGWs) for forwarding traffic from MANET to Internet and vice versa. Many recent works focus on the integration of ad hoc network with the pre-established communication infrastructure such as Internet or cellular network [7, 12]. To create such an integration a point is required which has interfaces connected both with the MANET and Internet. The nodes that enable the rest of the MANET to connect with Internet are named as Internet gateways. Mobile nodes have to discover those nodes which are formed as gateways.

Gateway Discovery is a method which allows a MANET node to discover an IGW via which traffic for the Internet can be delivered, and from which traffic returned from the internet can be received. The different discovery mechanisms can be classified into three sub-classes: proactive, reactive, and hybrid. In multiple gateway environments, a mobile node receives multiple gateway advertisements [4]. In proactive approach, Internet gateway periodically broadcasts gateway advertisement (GWADV) message proactively throughout MANET domain. These schemes cost heavy routing load since the gateway advertisements are broadcasted periodically even if there is no such demand from the nodes in the MANET [2-3]. However, proactive load-aware Internet gateway discovery scheme distributes the traffic evenly among the nodes in MANET as traffic/mobility increases.

In reactive schemes the gateway discovery is initiated by a mobile node that needs to create or update a route to a gateway. The mobile node broadcasts a route request (RREQ) with an ‘I’ flag (RREQ_I) to the IP address for the group of all gateways in a MANET (ALL_MANET_GW_MULTICAST Address.)
Thus, only the gateways are addressed by this message and only they process it. Intermediate mobile nodes that receive a RREQ_I are not allowed to answer it, so they just rebroadcast it. When a gateway receives a RREQ_I, it unicasts back a RREP_I which, among other things, contains the IP address of the gateway. The advantage of reactive gateway discovery scheme is that control messages are generated only when a mobile node needs information about reachable gateways. The disadvantage of reactive gateway discovery scheme is that a handover cannot be initiated before a mobile node loses its Internet connection. These schemes suffer interfaces to connect to the Internet directly. So the reactive approach a MANET node sends a solicitation and waits for a reply from the IGW and proactive approach requires much traffic overhead on the MANET, while the reactive approach causes higher delay [5].

A hybrid gateway discovery scheme [4] is a hybrid combination of the proactive and the reactive algorithms. In current work [1], gateways forward advertisements for a fixed and limited number (i.e., three) of hops. A MAN which does not receive an advertisement for a specified time period will additionally search for a gateway with the aid of solicitation messages. The hybrid approach compromises with the balance, in which each IGW periodically broadcasts the advertisement within the radius of n-hops [6]. Those MANET nodes which are located further than n-hops away from the IGW, must use the reactive approach to discover the IGW. A gateway discovery technique using HELLO packets is described in [6], which represents a testbed with a very small number of nodes within the cluster. Moreover, there is only one gateway implemented and therefore, no investigations were performed on handovers.

This paper addresses the limitation regarding fixed hop gateway advertisement of currently available hybrid scheme. In this paper, a novel hybrid scheme is proposed for both gateway discovery and selection. Unlike previous work, this proposed approach uses variable hop count for gateway advertisement, which allows the GWADV messages to be broadcasted for required distance. This hop count value is determined by the average hop count of all the nodes requesting gateway information during the advertisement interval. Thus, the GWADV messages are broadcasted to update most of the hosts in the network and the boundary or the distance covered by these GWADV messages, changes dynamically and could be different after each advertisement interval. Therefore, only a few GWADV messages are broadcasted which in turn increases the PDF/PDR (Packet delivery fraction/Packet delivery ratio) and decreases delay.

II. RELATED WORKS

Hamidian et al. [9] proposes an approach which provides internet connectivity to Ad Hoc networks by modifying the AODV routing protocol. An “I” flag is added as an extension to AODV, RREQ and RREP to locate the fixed node. If after one network-wide search without receiving any corresponding route replies, the mobile node assumes that the destination is a fixed node, which is located in the Internet and thus delivers the packets through a gateway. All the three methods of gateway discovery for a mobile node to access the internet are based on the number of physical hops to gateway as the metric for the gateway selection.

Chaba et al. proposed a gateway selection protocol that is used for hybrid MANETs. The multipath extension [11] is useful because if one path fails to carry the route, the data still can be routed through another path. It consists of two phases: one is request phase and the other one is reply phase. In request phase the source node broadcasts a route request (RREQ) packet to its neighbors and it is broadcasted until it reaches for the destined node. In the Reply phase the route reply (RREP) is sent to the source by the destination. This way the route cutoff problem is solved.

Sandhu et al. [10] proposed AODV+, an enhanced version of the AODV protocol. In the traditional AODV protocol the mobile node initiates the route discovery process by broadcasting the route request message (RREQ) with its own IP address as the source IP address and destination IP address of an internet host. When an intermediate node receives the RREQ packet, it searches its routing table for a route on the way to the destination i.e. the Internet host.

Some other research works [9, 12-14] proposed hybrid gateway discovery schemes where the time-to-live (TTL) value of the gateway advertisements is limited to a certain boundary to minimize the disadvantages of proactive and reactive schemes. However, these schemes require some intelligent adaptation of the TTL value.

Lee et al. [12] proposes two advertisement schemes based on observation of traffic and mobility pattern to avoid generating unnecessary routing overhead in MANET. Kumar et al. [15] used interface queue length along with the hop count to select a path to a gateway. But it cannot be applied in the reactive and hybrid strategy and also seems that it will work better under longer interface queue length. Juang et al. [16] provided an exponential back off algorithm and a controlled flooding algorithm to reduce network traffic due to reactive discovery. But none of these two algorithms provides any new solution for gateway discovery and selection. Ruiz et al. [14] proposed two new schemes for gateway discovery based on the dynamic adjustment of the scope of the gateway advertisement packets. Shin et al. [17] offered a new scheme for the gateway selection based on node mobility which requires high processing power consumption and nodes have to wait longer period of time to select a path to a gateway.

III. PROPOSED SCHEME

The current approaches of gateway discovery suffers from various disadvantages like in proactive method the control message floods through the whole MANET. In reactive method there is lack of handover chance, that means if needed nodes cannot change their gateway to the nearest one. So there remains chance of packet drops and congestions. Nodes can miss the route also. In previous Hybrid method which controls the disadvantages of proactive and reactive works for a fixed range according to the static hop count. This limitation of area supposed to have uncertainty of good outputs. So it cannot be said fully advantageous method of gateway operation.
This paper proposes a new solution for this kind of problems of previous works and adapts a novel Hybrid gateway discovery method, where the similar hop count is used to determine the zone of gateway advertisement but in a wider and adaptive way which overcomes the limit of the hop count range. It is no more working for a fixed area. Computation of the new radius of n-hops is based on an algorithm of average of route requester nodes according to hop count under gateway supervision. In the case of hybrid the gateway periodically broadcasts a message (i.e., GWADV) which is transmitted after expiration of the gateway’s timer, ADVERTISEMENT_INTERVAL. This is a period in which gateway sends the message of advertisement. This advertisement period is chosen with care so that the network is not flooded unnecessarily.

### Advertisement Interval

In our solution gateways acts proactively in a range which will be determined by the hop count average. And the rest of the MN will act reactively to get the feedback of gateway. In the area of our computation gateway discovery is initiated by the gateway itself. The gateway periodically broadcasts a message (i.e., GWADV) which is transmitted after expiration of the gateway’s timer, ADVERTISEMENT_INTERVAL. This is a period in which gateway sends the message of advertisement. This advertisement period is chosen with care so that the network is not flooded unnecessarily.

### Advertisement Zone

The maximum number of hops by which a GWADV message can travel through the MANET is determined by ADVERTISEMENT_ZONE. This value defines the range within which proactive gateway discovery is used but now the value will not be fixed anymore. New scheme will discover this ADVERTISEMENT_ZONE by using an average algorithm. Nodes are moveable and this mobility of the nodes can increase or decrease the range of this gateway ADVERTISEMENT_ZONE. The gateway will broadcast the GWADV for an advertisement interval. By this time as many nodes will be able to reach the gateway, will be taken in count. Their hop counts will be stored and the average of total will be granted as next ADVERTISEMENT_ZONE value. After the interval the storage will be turned to zero and within same interval next broadcast will be started.

### Average Hop Count Measurement

Here we consider two gateways and they will calculate their average hop count occupancy level in their surrounding area and to do that we modified the gateway circumstances used in AODV protocol. We also added three new fields first one is hop_count_sum_gw in gateway massage which will count the n-hop, secondly user_count_gw for the requestor and hop_count_avg_gw to record the average of the hop count. To count the average following criteria is used:

\[
\text{hop\_count\_avg\_gw} = \frac{\text{hop\_count\_sum\_gw}}{\text{user\_count\_gw}}
\]

The meanings are:

- **hop_count_sum_gw**: Hop count sum of a gateway
- **user_count_gw**: User address (per hop request)
- **hop_count_avg_gw**: Ratio between total summation of hops and number of user or requestor nodes.

At the starting of this algorithm the first field is taking the requestor hops in count according to their reply. So the value of user is increasing and getting stored with their proper addresses. Finally the mean of hop count is determined by the ratio between the hop count of the gateway and the user count. This is the procedure of average n-hop computation of the gateway. And this average value is been used as the next ADVERTISEMENT_ZONE. Thus the same process runs by repetition.

### TTL Value Determination

In the previous scheme of Hybrid the TTL (Time to leave the data packet) value was not adopted properly and not fixed as infinity as proactive so flooding content takes place loudly, which isn't logical. To limit the flooding of advertisements the TTL value of the gateway advertisements is set to the distance of the source form the gateway. It will be adopted by the hop count found by the average algorithm and is shown by following:

Here it is shown that the ultimate destination of average value is ultimately the TTL. Upon receipt of a GWADV message, firstly TTL will be decremented by the mobile nodes until it turns to zero that means the nodes will start to drop GWADV packets from the maximum TTL value and then will join the corresponding gateway operation. The rest of the zone that means outside of hybrid nodes will use gateway reactively.

### IV. SIMULATION SETUP AND RESULT ANALYSIS

#### A. Parameters Setup

We implemented our solution in NS-2 [18] and compared it with the previous Hybrid scheme. To make this comparison of previous work with our new hybrid scheme we studied the scenario consists of 60 mobile nodes, two gateways, two routers and two hosts. The topology is a rectangular area with 1300 m length and 800 m width. With the same node density a rectangular area was chosen compared to a square area in order to force the use of longer routes between the nodes,. The two gateways were placed on each side of the area; their x- and y-coordinates in meters are (200,500) and (1100, 500). The
simulation time is 1000 seconds. Ten of the 60 mobile nodes are constant bit rate (CBR) traffic sources sending data packets with a size of 512 bytes, to one of the two hosts, chosen randomly. The sources are distributed randomly within the MANET. The transmission range of the mobile nodes is 250 meters.

The mobile nodes move according to an improved version of the commonly used random waypoint model. It has been shown that the original random waypoint model can generate misleading results [20]. Each mobile node begins the simulation by selecting a random destination in the defined area and moves to that destination at a random speed. The random speed is distributed uniformly in the interval [19,20] m/s. Upon reaching the destination, the mobile node pauses for 10 seconds, selects another destination, and proceeds as described. This pattern of movement is repeated for the duration of the simulation. The gateways broadcast GWADVs every ADVERTISEMENT_INTERVAL=5 seconds. We considered the traffic load which varies from 90,100,110,120,130,140,150kb/s.

We also implemented the simulation on different speed for the comparison of our scheme with the previous. The mobility model used in this study is the Random Waypoint Model [19] and the communication type is CBR (constant bit rate). The simulation was run for a total of 1000 seconds with a pause time of 10 seconds and seed time of 0.25 seconds for each case. We take the Packet delivery ratio and delay performance and normalized ratio load of the whole network against the speed of the nodes which varies from 2, 5, 10, 15, 20, 25 and 30 meter/second. The wireless channel bandwidth of nodes is set to 2Mbps and the wired link bandwidth of the gateways and hosts is set to 10Mbps.

B. Performance Metrics

We use the following performance metrics for comparison:

The packet delivery ratio: This is defined as the number of received data packets divided by the number of generated data packets.

The end-to-end delay: It is defined as the time a data packet is received by the destination minus the time the data packet is generated by the source.

Normalized routing load: This defines the ratio between number of AODV routing packet/AODV messages transmitted by the nodes in MANET and the data packets received by the Internet hosts. It is also called The Normalized Control Overhead (NCO).

C. Result Analysis

We termed the curves found with our solution as “Hybrid-Novel” in the graphs. Simulation results show that our one beats the previous Hybrid in the three performance metrics. In Fig.1 it is showing that when the ADVERTISEMENT_ZONE is changing inconsistently and the traffic load is increasing though the packet delivery ratio has been increased. Simulation research shows that under the load of 90, 95,100,110,120,125,130, 135, the ratio is comparatively better as it could be take in consideration that across this load nodes can find out any other shortest path to achieve the packet transmission goal.

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this in Fig. 2 the curve of hybrid novel shows that the End to End Delay that means the intermediate time to send-receive a data packet is less than the previous Hybrid. As the range of Hybrid is extended and less area is using reactive protocol it needs less time to deliver a data packet than the previous one. From Fig. 3 we can see that our scheme performs well than the previous with respect to NRL performance metric also. The normalized routing load is low in the graph and it means that tour system is not suffering from packet drops and miss route. It is easy to assume as the packet delivery is high so the drop of packets will be low. As the control message flooding is prevented and handover is initiated. Across the all the loads when the last node according to hop count gets the GAWDV message only that drops the message and stop rebroadcasting. So it can be said that the few packet drops that the graph is showing maximum has happened for this reason.

Fig. 4 shows that with the variation of speed the packet data ratio comes better it means more packet delivery has done even than also, when the nodes are in high speed. As the mobile nodes are unpredictable in movement and it can move sometimes slow and sometimes high so it’s tough to predict that in which area it will be available after a certain time. With the speed model our hybrid scheme has an extra facility that is the more nodes enter the advertisement zone the more it is effective to have good packet delivery ratio. Fig. 5 respectively shows how much time it takes to deliver the packets when the nodes move with the high speed. In comparison of previous hybrid scheme our one performs better because the average end-to-end delay has decreased. Packet delivery is high with less delay because the nodes don’t have to wait for a long to rebroadcasting of control message and also the mobility model is effective on this. We can now say it performed well in fewer packet dropping also because Fig:6 proves that NRL increases with the speed of the mobile nodes in previous Hybrid scheme as the zone of advertisement was fixed in that and TTL value was limited so no other nodes were permitted to take entry in hybrid and they have to act reactively which caused more packet drops and also more delay. However, our scheme has less NRL than that of the previous Hybrid because the range is adaptive now and more and more nodes are permitted to enter the zone with their speed level and to take part in packet delivery. So it has less packet dropouts and it requires less time to increase packet delivery ratio compared to that of the other hybrid scheme.

From the above analysis of the results, we can conclude that our proposed gateway discovery and selection scheme will scale well with the number of nodes, the traffic load and the speed of the nodes.

V. CONCLUSION

A successful try to integrate mobile ad hoc network and Internet provides overall good Internet services for mobile users in a MANET. In this paper we proposed a hybrid scheme based on average hop count during the time of advertisement of a gateway which is a successful attempt of mobile ad hoc network integration. The proposed scheme prevents previous hybrid scheme’s limitation. It has worked for a wide range where advertisement zone exponentially determined by an adaptive value per hope count mean. So less area has to use the reactive protocol thus lack of handover problem remedies. TTL value is adopted properly and it gets fixed by the amount of node entries in the zone. Simulation scenario and comparison measures this idea gives less End to End delay better Packet data fraction and normalized ratio of packet is quite less which proves less flooding. The mobility model explains that how speedily a mobile node moves and get into the zone and in different speed ratio how this novel hybrid method works better. The simulation result shows that between particular load ranges packet data ratio becomes better. It is because across those traffics, the nodes find out a better way of sending packets as the existing path becomes very congested.
REFERENCES


