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Gateway Discovery and Gateway Selection Schemes for Connecting MANET and Internet: A Review

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Abstract: Mobile ad hoc networks are emerging as one of the most popular network used in many applications and deploy easily. Since these networks are infrastructure free, therefore no fixed mechanism for communication between mobile node to mobile node and mobile node to gateways. Researchers proposed many solutions to provide internet connectivity in MANET. The two main challenges in MANET-Internet connectivity are gateway discovery and gateway selection. Many researchers work in this field and given a number of solutions to discover the gateway and select the most effective one. This paper presents the mechanism of gateway discovery and selection schemes by describing the previous and present work.

Keywords: MANET, Gateway Discovery, Gateway Selection, Advertisement, Hop Count.

I. INTRODUCTION

A mobile ad hoc network defines a collection of mobile nodes that can communicate with one another without using any fixed networking infrastructure. These communication is maintained by the transmission of the data packets over a common wireless channel, since no base station are required, thus ad hoc network can be deployed quickly without having to perform any advance planning of network infrastructure. The design of ad hoc network faces many challenges .one main challenge is that all nodes in ad hoc network including source and destination nodes as well as routing nodes may be mobile so the topology may frequently change .The increase of wireless portable devices such as mobile phones laptop and PDAs lead the people desire to connect with a stable and excellent network connection at anytime, anywhere. Therefore connection of MANET and Internet is a key problem in current academe. Due to different routing mode of MANETs and Internet, there should have a special gateway between them as a bridge for connecting of MANET to the internet. Whenever a mobile node wants to connect with internet, first it has to search for the gateways which are called as gateway discovery .Then according to the effective gateway selection schemes mobile node selects the most optimal gateway candidates. Thus gateway discovery and gateway selection techniques are hotspot research zone in ad hoc networks. This paper we pay more attention on the study of gateway methods implemented to connect the mobile nodes with internet. This paper firstly describes the gateway discovery schemes in mobile ad hoc networks and includes some of very effective mechanisms and their working procedure. Then gives the gateway selection schemes proposed by researchers and finally tabulates some of characteristics of these approaches. All these description of proactive, reactive and hybrid approaches will provide a better understanding of previous works in these fields so researcher can choose a proper approach from their aspects and desire.

II. GATEWAY DISCOVERY

Gateway discovery schemes are important to discover a route to the gateway There are mainly three approaches for gateway discovery in MANET: Proactive, reactive and hybrid approach. Hybrid approach can be classified into normal hybrid approach, adaptive gateway discovery approach, Secure and QoS aware gateway discovery approach.

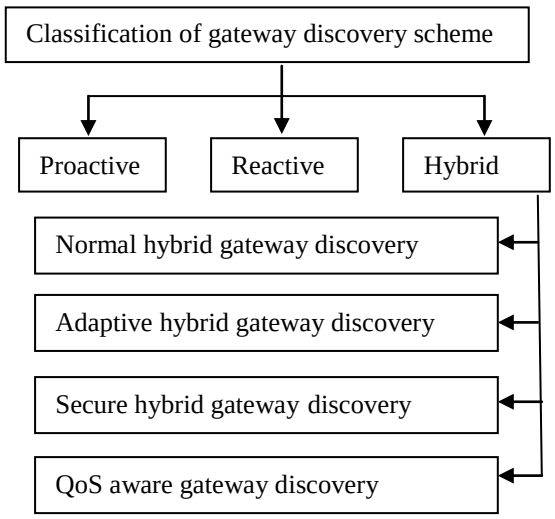

Fig. 1 Classification of gateway discovery scheme

The gateway discovery scheme is important to discover a route to the gateway , since the structure of MANET is

infrastructure free , so it requires a way to discover a route to the gateway to have accessing the Internet. The gateway schemes based on three types of discovery proactive, reactive and hybrid schemes:

A. Proactive Gateway Discovery Approach

In proactive gateway discovery the gateway itself initiate the Gateway discovery process by broadcasting gateway advertisement messages (GWADV).These GWADV message are broadcast periodically at the time of ADVERTISEMENT- INTERVAL and the entire mobile node in that transmission area receive this advertisement. After receiving the message the mobile nodes stores the route information to the gateway or they update their route table if they had any previous entry for the gateway .Thus all the mobile nodes comes under that proactive transmission range get updated. There are many approaches implemented by using proactive gateway discovery .Some of them are described here.

Khan et al. [1] proposed a proactive gateway discovery scheme that allows routing table for each mobile node to store the number of hops, sequence number for all destinations. The routing table updates periodically. The interval between two update is known as the periodic route update interval. DSDV protocol used in this approach since in DSDV packet delivery ratio is very slow because of stale route due to broken links. Therefore packet can be forwarded through other neighbour who may have routes to the destination. Whenever a link is broken DSDV create a temporary link through the neighbour having a valid route to the destination. To create a temporary link a one hop request ROUTE_ACK is send.

Robert Brannstrom et al. [2] a scheme which is implemented by connecting multi hop network with the internet which reduces delay in the gateway process. Advertisements are arrived through the multi hop paths; it is required to keep track of the best path to each gateway. This approach uses the running variance metrics (RVM) and relative network load (RNL) for performance metrics to the traffic load of gateways in MANET.

C.Jelger et al. [3] proposed a proactive gateway discovery approach in which gateways periodically advertise their presence by flooding gateway information (GW_INFO) messages. This proposal used a restricted flooding scheme, to limit the overhead of the proactive gateway discovery. Prefix continuity is implemented to ensure that every node has same prefix and each gateway only receives IPv6 data packets belonging to its prefix. After receiving the GW_INFO message mobile node (source node) configure an IPv6 address based on the advertised prefix and sends only the GW_INFO message including the selected prefix. The nodes concatenate interface identifier to one of those prefixes to generate IP address. Route selection is done by using the metrics such as distance, stability or delay from all the gateway information messages received by the mobile node.

B. Reactive Gateway Discovery Approach

Reactive gateway discovery scheme initiate the discovery process by the mobile nodes. Whenever a mobile node wants to connect with the internet, it broadcast a gateway solicitation message (GWSOL) to find the gateway. If MANET is using reactive routing protocol, node may send the Route Request packet (RREQ) including the gateway solicitation message for all gateways When there has a need of internet connectivity, mobile node broadcast a RREQ message with an 'I' flag (RREQ_I) to all the gateway present in MANET, which is the IP address for the group of all gateways in a MANET. When a gateway receive a RREQ_I, it unicasts back a RREP_I packet containing IP address of the gateway to the source node. After receiving the RREP_I source node can create path to gateway. Ammari et al. [4] proposed scheme is based on three-layer approach using Mobile protocol and DSDV ad hoc routing protocol. The first layer contains Mobile IP foreign agents, the second layer contains mobile gateways and mobile internet nodes having one hop distance from Mobile IP foreign agents, the third layer includes all MANET nodes and visiting mobile internet nodes that are at least one hop away from gateways. Second layer provide internet connectivity to mobile nodes .Mobile gateways are designed to use both Mobile IP.DSDV protocol is for routing packets in MANET.

C. Hybrid Gateway Discovery Approach

Hybrid discovery gateway discovery combines the best of both proactive and reactive approaches .All the mobile nodes in a certain range (which is decided by a limited number of hops which is called as TTL) around a gateway use the proactive gateway discovery scheme while the mobile node residing outside that range use reactive gateway discovery to communicate with gateway.

Iqbal et al. [5] proposed a gateway discovery and selection scheme where the gateways advertise gateway advertisements messages only on-demand. These advertisements follow certain order to make this scheme scalable. Whenever a mobile node wants to access the Internet, the gateway discovery scheme looks into the routing table to find the default route. If a mobile node does not find the route a gateway discovery process starts broadcasting a gateway discovery message (GWDSC) in the MANET. The requesting mobile node also set a TTL value for the message. All intermediate nodes after receiving this message create a reverse route entry for the requestor and forward the GWDSC message to its neighbours. When a gateway receives the GWDSC message it broadcast a GWADV message. This scheme also proposed to set a TTL value equal to the distance from the gateway to the requesting mobile node. They also add two new fields **Q** and **N** respectively with conventional fields. Q to represent total interface queue size of nodes along a route from gateway to mobile node and N represents total number of neighbours. Figure 2 shows the format of GWADV message.

Thus, this gateway discovery scheme requests for the gateway by GWDSC message as reactive scheme, broadcast of GWADV message like proactive scheme and sets the TTL value for GWADV like hybrid scheme. It combines the best of all the three approaches which makes this discovery scheme more effective and faster.

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0	8				12	24 31
Type	J	R	G	I	Reserved	Hop Count
RREQ_ID						
Destination IP Address						
Destination Sequence Number						
Originator IP Address						
Originator Sequence Number						

Fig. 2 Format of GWDSC message in our scheme

0	8	19	24 31
Type	Reserved	Pref. Size.	Hop Count
Broadcast ID			
Destination IP Address			
Destination Sequence Number			
Sequence IP Address			
Life Time			
Q			
N			

Fig. 3 Format of GWDSC message in our Scheme

The selection part of this scheme is done by a new composite metric **gateway cost (gc),** which is composed by three factors: hop count, interface queue size and calculate the value of gc;

$$\mathbf{gc_q = hc_q + Q/(Q+1) + N/(N+1)}$$

$\mathbf{hc_q}$ $\mathbf{hc_q}$

$\mathbf{Q} \in$ VGW $\mathbf{Q = \sum_{i=1} int\_q\_size}$ $\mathbf{N = \sum_{i=1} n_i}$

When a node p in a MANET receives a GWADV message from a gateway q, the above equation is used to calculate the gateway cost. Where V_{GW} is the set of internet gateways in the network, hc_q represents number of hops from q to p, $int\_q\_size_i$ represents interface queue size of node I along the route from q to p , n_i represents the number of neighbours of node i along the route from gateway q to node p. Therefore this approach used metric gc to selects the path which have lesser load and less dense path and selects the shortest path.

There are some further classification of hybrid gateway discovery approach are used by researchers such as normal gateway discovery, adaptive gateway discovery, secure hybrid Gateway discovery and QoS-aware gateway discovery approach. We are describing some of these schemes here:

Adaptive gateway discovery algorithm routes those data packets that it would received anyway it means that can easily provide the information. In these approach number hops of its active source location is maintained.

Broach et al. [6] proposed an adaptive scheme for the integration of MANET with Mobile IP using a source routing protocol. It contains a border router having two interfaces.DSR routing protocol is used to communicate within the network. While its interface connected to the network is configured to use normal IP routing protocol.

Bin et al. [7] proposed adaptive gateway discovery scheme in which TTL can dynamically adjust its value of GWADV. Mobile IP is used to provide the internet access to the mobile nodes. Foreign agents track the data packet and forward them to and from the mobile node. To adjust the value of TTL foreign agents periodically calculates the average hops by RREQ_I messages or registration request sent by mobile nodes requesting internet connectivity.

Alicia Trivino et al. [8] also proposed an adaptive gateway discovery. This mechanism adapts the interval of emission of MRA messages to the mobility and traffic condition of the MANET. Mobile nodes generate the Modified Router Solicitation (MRS) messages in an interval of time called the MRS_COUNT_INTERVAL. High the number of received MRS messages as high the mobility and higher the need of updating the routes to the internet. Therefore its decreases the loss and lower the overhead. The observation of mobility of nodes is done by sending the MRS messages and predicts the numbers of requests are expected to be received by the gateway in the next interval. By taking all these information the decision is based on the present and past behaviour of the network

Ahmed et al. [9] proposed a trust based secure gateway discovery scheme which employs the concept of mutual trust and authentication among nodes. This approach provides an effective and adaptive load balancing scheme to avoid congestion on route or overflow in the interface queue. To connect with the internet, a mobile node needs to discover a route to gateway and register with that. The figure 4 represents a scenario of the proposed gateway discovery scheme:

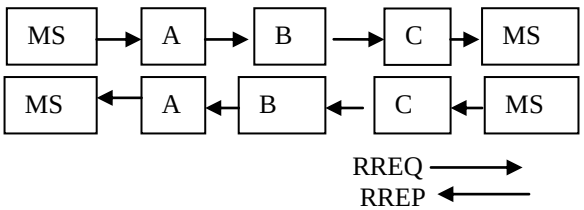

Fig. 4 A scenario of propagation of GWSol message

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Whenever mobile nodes want an internet connection they broadcasts a gateway solicitation messages GWSol to their neighbours. This message use private key of MN .When any Neighbour node receives this request it check the validity by using public key, timestamps and nonce. This sequence is followed by each intermediate node. When a gateway receives the request it forwards the request to FA who creates the mobility and gives the authentication for received message and sends advertisement. After receiving the advertisement from the FA gateway generates the route reply by embedding this advertisement and unicast it on reverse path. If the source mobile may receive multiple route replies from the gateways then the source node computes the metric Route Selection Value (RSV) .The proposed metric equation is as follows:

$$\mathbf{RSV:= \alpha_1 (RT_i / RT_{avg)} + \alpha_2 (H_i / H_{avg}) + \alpha_3 (Cr / C_{max})}$$

The α_1, α_2 and α_3 are predefined constant and their range goes from 0 to 1.Their values are depends on node mobility and application types. RT_i represents the route trust value observed by I, RT_{avg} is the average route trust of all received route replies, H_i and H_{avg} represents hop count and average hop count of all received routes respectively. C_r is the residual route load capacity of a route.

III.GATEWAY SELECTION SCHEME

Gateway selection scheme work where multiple gateways are discovered .Majority of current gateway selection schemes use the hop count to select the best gateway. These hop count based selection scheme choose the nearest gateway .In this case if always the nearest gateway will be selected then under the heavy traffic load it might create congestion into the network. Thus only hop count metric is not suitable for the selection not the gateway. Few researchers considered the traffic load in addition to the hop count to select the best gateway. Le-Trung et al. [10] proposed a hybrid metric that provides load balancing of intra/inter-MANET traffic for internet gateway selection. This selection schemes introduces extra routing load and requires high processing power consumption to compute the hybrid metric.

Zhayang et al. [11] considered the speed of a node for selecting the gateway; it may impose additional cost by limiting the applicability of the work. Kumar [12] considered the number of packets waiting in the interface queue of the nodes to select the gateway. [13] considered the number of packets waiting in the routing queue of the nodes to select a gateway.

Park et al. [14] proposed a selection scheme based on the packet arrival rate of a gateway in an interval as the traffic load. A decision function is used for the traffic load and hop count to select a gateway. Piggybacking is required at each intermediate node to load the information at certain interval, which increases the header size of the data packets.

Trivino et al. [15] considered two factors to select the gateway; first one is Minimum Hop Count Criteria which states that gateway will be selected if the number of hops between the MANET node and the gateway utilization is less. Second one is maximum gateway utilization criterion where a node uses the same gateway until it goes outside the range of that network. When the nodes stops receiving the corresponding MRA (Modified Router Advertisement) messages it means they are unreachable for the ad hoc network.

Yogesh Chaba et al. [16] proposed a scheme that uses two phases to ensure multipath extension in case one of the paths fails the data can be routed through another path. First phase is request phase in which source node broadcasts a route request packet (RREQ) to its neighbours until it reaches to the destination node. Second one is reply phase where the route reply is sent to the source by the destination. Shortest distance between nodes and gateway, traffic load and energy at the IGW are the metrics used for gateway selection.

[17] Proposed a gateway selection scheme based on orthogonal genetic algorithm and sensitivity analysis and which includes hop count, gateway load and path quality. They also used the average packet size, maximum packet queue size and an index α to compute the gateway load.

Takeshi Matsudo [18] proposed a novel gateway selection protocol in hybrid Mobile ad hoc networks Focusing on the situation that occurs when sensitive data is sent to the internet from MANET nodes. It is necessary for such special data to be forwarded by a trusted secure gateway. The proposed scheme achieved this by enabling the routing protocol to allow selection of GW depending on the sensitivity of data from multiple GWs provides internet connectivity and only trusted GW scan be used to forward sensitive data to the internet, this selection mechanism done by a modification in DYMO protocol to discover the routes to appropriate GW depending upon the type of application data.

Shailesh Kumar [19] introduce how to improve the network performances based on select a gateway with stable path ,minimum packet loss rate between two neighbour node, a path to the maximum residual load capacity and the minimum latency. The proposed schemes considers some service path parameters such as path availability period, available capacity latency and link quality to select a potential gateway node to ensure the improvement in performance of the network. R. Manoharan et al. [20] is based on load capacity which is calculated by packet size and packet arrival rate, each node calculate load capacity and compare it with the load capacity received from previous node and so on until arrive the gateway. The route trust calculated by node assigned a value between 1 and -1.node m in route from node n gives trust value 0 represent normal node, trust value 1 represent trusted node and -1 represents malicious node.

IV.PROPOSED SCHEME COMPARISON

The comparison of different proposed schemes discussed above is illustrated in Table 1.

Table 1 Proposed Scheme Comparison

Proposed Scheme	Gateway Scheme	Gateway Selection Scheme	Connectivity based on gateway scheme	latency
Khan [1]	Proactive	Hop count, Path load	Best	Lowest
Jelger [2]	Proactive	Path quality based	Best	Lowest
Ammari [4]	Reactive	Hop count, Path load	Worst	Highest
Alicia [7]	Reactive	Hop count	Worst	Highest
Parl [12]	Adaptive	Gateway Load based	Better	Lower
Yogesh [14]	Reactive	Hop count, Path load and Energy load	Worst	Highest

V. CONCLUSION

This paper we first describe the gateway discovery scheme and represent the different approaches given by researchers. By these gateway discovery schemes we can conclude that pure proactive and reactive approaches are easy to implement but they may increase overload, delay and congestion problems. However hybrid approach includes the best of both proactive and reactive schemes in addition with some new metrics. In case of connectivity proactive gives better connection than reactive and hybrid approach. But in case of overhead proactive have the highest and hybrid approaches gives lesser overhead. Thus we can conclude that hybrid has the best stability, less overhead and better packet delivery.

When it comes to gateway selection procedure the result is same. Gateway selection schemes are based on various parameters. One or more than one parameter are taken together to select the gateway. Main objective in gateway selection is to get the shortest path, minimum overload by selecting the most effective gateway to communicate with internet. Future works includes the modification in these given approaches and make it more effective or with the help of these approaches may find out a novel gateway discovery and gateway selection scheme.

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