A Simplified Scheme of Internet Gateway Discovery and Selection for MANET

Xu zhanyang * **
* Institute of Information Network Technology
Nanjing University of Posts and Telecommunications,
Nanjing, China
** Department of Computer Sciences,
Nanjing University of Information Science and Technology,
Nanjing, China
zy_xu2004@hotmail.com

Han xiaoxuan
Sino-German Institute
Tongji University
Shanghai, China
xx_han_x@hotmail.com

Zhang shunyi
Institute of Information Network Technology
Nanjing University of Posts and Telecommunications
Nanjing, China
dirzsy@njupt.edu.cn

***Abstract*—When the mobile ad hoc network (MANET) is connected to the Internet, it is important for the mobile nodes to detect available Internet gateway (IGW) providing access to the Internet. We propose a new structure—virtual MANET（V_MANET）for MANET to connect with Internet. In the structure, the IGWs are seen as a fixed node in MANET and act as a proxy server in the local area network (LAN). At the same time, we develop the IGWs discovery, Deleting IGW, Exchanging IGW _INFO between two neighbor nodes and IGW selection algorithm applied in the V_MANET. The result of evaluation shows that our architecture and these algorithms can improve network performance and is more efficient.**

Keyword—V_MANET; IGW; IGWs discovery and selection;

I. INTRODUCTION

Based on limited bandwidth and energy resources, the mobile ad hoc network (MANET)[1][2] is a network that is formed without any established infrastructure or centralized administration. The flexibility, easy deployment and self-configurability of mobile ad hoc networks are the most important features of the MANET. During an event place such as nature disaster, it is almost impossible to communicate through any fixed infrastructure due to deployment cost. With the features introduced above, MANETs can be deployed quite easily and efficiently at any place on temporary purpose.

In addition, with the advent of future wireless systems consisting of an integration of different heterogeneous wireless technologies, the interconnection of MANETs to fixed IP networks is one of the areas which are becoming critically important. Some nodes in fixed network act as "Internet gateways" (IGWs) which can be used by mobile nodes to seamlessly communicate with other nodes in the fixed network. So, an efficient IGW discovery and selection for the nodes of MANET to connect with Internet becomes the key elements. Unlike the connection of the fixed LAN and Internet, there are many factors between MANET and Internet that should be considered due to the limitation of bandwidth and energy of the hosts in MANET [3].

In this paper, a virtual MANET (V_MANET) structure is proposed. In the structure, The IGW is seen as an unmoving node in the MANET. Based on Ad hoc On-demand Distance Vector Routing (AODV) [4] used in the V_MANET, we propose the simplified approach of IGW discovery and selection.

The remainder of this paper is organized as follows: In section 2, we discuss the related work regarding IGW discovery and selection mechanism, as well as their performances. In section 3, we present a new approach based on hops to solve the inadequacies of the existing methods. The implementation algorithms will also be described. Section 4 simulates and summarizes our approach. A conclusion is given in Section 5.

II. RELATED WORK

In the literature, lots of new protocols for connecting MANET with the Internet have been proposed. Methods to interconnect MANET and select the route to the Internet for the nodes of MANET have also been discussed in some papers. Those methods can usually be classified into three subclasses by the IGW discovery mechanism [5][6]: proactive, reactive, or hybrid.

In the proactive approach, such as in [7] [8], each IGW broadcast periodically the gateway advertisement message (GWADV) to the nodes in the MANET connected, which are flooded throughout the entire ad hoc network. And all mobile nodes residing in the IGW's transmission range receive this advertisement. According to the received advertisement received, the mobile nodes without a route to the IGW create a route entry for it in their routing tables; otherwise updating their entry for the IGW. Next, the advertisement is forwarded by the mobile nodes to other nodes residing in their transmission range. In this approach, there is only one route to an IGW. In the scheme, due to the GWAD message broadcasted in the coverage of IGW and forwarded in the MANET, there may be more overhead.

The reactive gateway discovery schemes allow the mobile nodes to broadcast gateway solicitation messages (GWSOLs) to find the proper gateway as they are needed [9] [10]. In the reactive approach, the reactive routing protocol (mainly AODV) is used. At each time when a node in the MANET wants to connect to the Internet, it needs to rebroadcast gateway solicitation messages in the MANET and waits for a reply from the IGW. There may be more end-to-end delay.

Supported by National High-Tech Research and Development Plan (863) of China (No.2006AA01Z232, No.2009AA01Z212, No.200901Z202), Natural Science Foundation of Jiangsu Province (No. BK2007603); High-Tech Research Plan of Jiangsu Province (No.BG2007045); Research Climbing Project of NJUPT (No.NY2007044); Foundation of Nanjing University of Information Science and Technology(NO.20070025)

978-1-4244-3693-4/09/$25.00 ©2009 IEEE

The hybrid gateway discovery [11][12][13] is a compromise of proactive and reactive mechanisms, in which each IGW broadcast periodically the advertisement within the radius of n-hop. MANET nodes, which are located further n-hop from the IGW, use the reactive approach for IGW discovery.

III. GATEWAY DISCOVERY AND SELECTION ALGORITHM

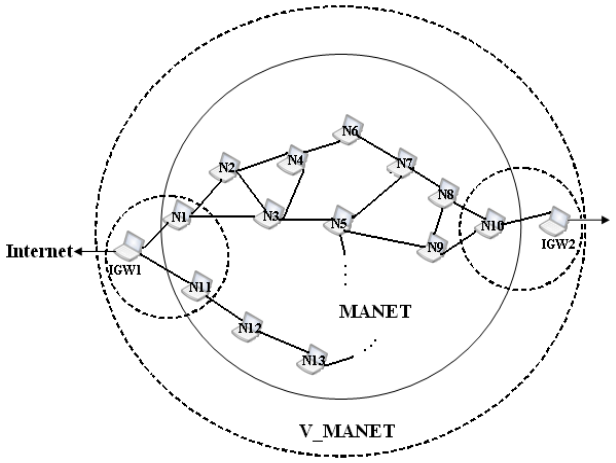

Fig.1 The Structure of V_MANET

The structure proposed of the network in our study is shown in the Fig.1. AODV routing protocol is chosen as the routing protocol. There are one or more nodes residing in fixed network, acting as an IGWs for the mobile nodes of MANET connecting to the Internet. When these IGWs are connected to the MANET, IGWS and others nodes in the MANET will compose a new MANET which be called a virtual MANET (V_MANET), the IGWs will act as the proxy servers in the wired LAN. In the V_MANET, IGWs and mobile nodes have the same IP addresses used. Every node in the MANET willing to communicate with Internet needs to know the IGW IP. Although the mobile node knows all IGWs' IP in the V_MANET, there is no significant increase in the overhead due to small IGWs usage.

In every node in the V_MANET but the IGW node, the IGW information (IGW _INFO) is added into the maintaining routing message based on AODV, and needed not to be sent separately. The IGW _INFO is seen in the table1 for node N3.

Table1 IGW _INFO in Node N3

IGW_IP	Nbor_IP	Hop_Num
IGW1_IP	N1_IP	1
IGW2_IP	N4_IP	5
IGW2_IP	N5_IP	3

Message and Variable definitions

IGW_INFO(gateway information): where the gateway connected with one node will be recorded. The IGW_INFO added on the AODV message will be exchanged between neighbor nodes.

IGW_INFO.State: if the value is 0, it means there is no change in IGW_INFO in a node. If the value is 1, there are some change.

IGW_IP (Gateway IP): it is the IP address of the IGW. The IGW_IP is only used in the V_MANET and is unique.

Nbor_IP (Neighbor IP): it is the IP address of neighbor node, the IP address is only used in the MANET.

Hop_num (Hop number): it is the number of hops. And it is the shortest hop-distance from a gateway through its neighbor node. If the value of Hop_num is 0, it means the node directly connects with the IGW.

The IGW node will periodically broadcast the GWADV only in its' coverage area. A node moving into the coverage area receives the GWADV message, but does not rebroadcast the GWADV message to its' neighbor nodes. And the IGW _INFO written in GW _INFO table of the node is exchanged with its neighbors according to the gateway discovery algorithm described below.

In short words, , all nodes in MANET will have the information about the IGW node including the distance from IGW based on hops. Every IGW is discovered in the same way. The algorithm is described in the following section.

A. IGWs Discovery Algorithm

Referring to Fig.1, the Node N1 moved into the coverage area of the IGW1, and received a GWADV message from IGW1. The N1 will do the following:

1) If the IGW1.IP has been in entries in N1.INFO;

Then delete all entries with IGW_IP()==IGW1.IP;

IGW1 is added into a new entry in N1.INFO.

2) for this entry:

IGW_IP() = IGW1_IP;

Nbor_IP()= IGW1_IP; // set the IP of neighbor node with IGW1_IP.

Hop_Num()=0; // N1 is directly connected with the IGW1.

B. Deleting IGW Algorithm

When a node (such as N3) could not receive the IGW_INFO of its neighbor (such as N2) due to moving out or invalidation, N3 will do the followings:

1) In N3.IGW_INFO, for every entry,

If its' Nbor_IP() == N2.IP;

If, in N3 node, there is only one entry to the IGW1 through N2;

Then its' Hop_Num()=∞; // the N3's distance from the IGW through N2 node is set to ∞. That means the route to the IGW through N2is now not up to.

Else

delete the entry with Nbor_IP() == N2.IP;

2) The N3.IGW_INFO is sent to its' neighbor node attached to the route maintenance information.

3) In N3.IGW_INFO, the entry with Hop_Num()=∞ will be deleted.

C. Exchanging IGW _INFO Algorithm

The IGW_INFO is exchanged between neighbors. For example, when N3 gets N2.IGW_INFO from N2, it will do the following:

1) In N2.IGW_INFO received, If the N2.IGW_INFO.State==0;

   Then nothing will be done in N3;

   Else do followings; // if in N2, there is no any change about GWI_INFO, only the N2.IGW_INFO.State==1 is attached to the routing maintaining message.

2) In N2.IGW_INFO received, if a entry with Nbor_IP()==N3.IP, then delete it; // it means that N2 is connect to a IGW through N3.

3) If a entry's Nbor_IP()In N2.IGW_INFO received is the same as a entry's Nbor_IP()In N3.IGW_INFO; then delete it; // the neighbor node of N2 is same as the N3's, means that N2 and N3 nodes are connected with a IGW through the same node.

4) In N2.IGW_INFO received, if there is a entry with Hop_Num()==∞; then delete it;

   At the same time, in N3.INFO.

   If there is only one entry up to IGW1 through the N2 node;

   Then the entry's Hop_Num()will be set to ∞;

   Else delete the entry (up to GW1) with Nbor_IP()==IGW1_IP.

5) In N2.IGW_INFO received, delete all the entries up to the same IGW except the entry with minimum of Hop_Num() in them.

6) for every entry, Nbor_IP is replaced with N2.IP;

7) In N2.IGW_INFO received, for every record, Hop_Num()=Hop_Num()+1;

8) Then, these records of IGWs in N2.IGW_INFO received are added into N3.IGW_INFO;

D. IGW Selection Algorithm

When a node wants to connect with Internet to sent the packets.

If there is no entry in its' IGW_INFO or every entry with Hop_Num()=∞;

then the IGW is not up to;

else

the node will chose the IGW with the minimum value of Hop_Num() as the destination IGW in IGW_INFO.

IV. EVALUATION

The architecture of V_MANET proposed in the papers is more in line with the practical architecture for connecting MANET with Internet. Generally, there are not too many IGWs to be used for the MANET. In the IGW discovery, the overhead will be reduced, for there are no GWADV broadcasted and flooded in the V_MANET, the information about the IGWs is only exchanged between the neighbors. At the same time, a node could choose another IGW as its' destination when an IGW route is deleted. There is no need to restart to find the path because it records all IGWs. The delay is significantly reduced.

For IGW discovery, the approach is a kind of proactive approach in the coverage area of the IGW. Out of the coverage area, the IGW discovery is implemented through routing maintaining message attached to the IGW_INFO. When there is no change in IGW_INFO of a node, IGW_INFO.State is set to 0 and sent to the neighbor node without other message sent, so, the "Exchanging IGW _INFO algorithm" will not be done. For the IGW selection, the node takes less time to select the destination IGW because all IGWs' information has been recorded in the IGW_INFO. Therefore, our architecture and approach result in significant decrease of end-to-end delay and increase of throughput of the system.

We evaluate the performance of V_MANET in the following aspects.

1) The overhead of the IGW discovery.

2) The delay consists of the end-to-end delay for connecting an IGW and the delay of discovering a new IGW because of the change of the MANET topology.

We adopt NS2-2.29 to simulate the approach for performance evaluation. In the simulation environment, there are 20 mobile nodes distributed over a 600m*600m square simulation area and two IGWs connected with the Internet. At the same time, there are 6 mobile nodes accessing Internet source. The sending rate in MANET is 3840 bits/s. The nodes move randomly for 900 seconds of simulated time. Table 2 shows the results than other approaches.

The result shows that our architecture can improve network performance and is more efficient.

Table2 SIMULATION RESULT

Discovery approach	Aggregated throughput (Bit/s)	Packet delivery ratio	Average delay (ms)
proactive	34180	83%	19
reactive	40800	88%	32
V_MANET	41200	92%	15

V. CONCLUSIONS

In our architecture, because the IGW is seen as an unmoving node in the MANET, the complexity of architecture is significantly reduced, and the algorithm of the IGW is simpler and easier to be implemented. The problem of overhead and delay can be alleviated through the select strategy, and the performance of networks can be improved. The routing of gateway information can be directly obtained with routing remaining message based AODV. For the further research, we could add some special services, such as the security performance and QoS, into the algorithm.

REFERENCES

[1] T. Shivaprakash, G. S. Badrinath, K.R. Venugopal, L.M. Patnaik " Lifetime Maximization of Heterogeneous Wireless AdHoc Networks". In IEEE Proceedings of International Conference on Intelligent Sensing and Information Processing, IEEE Computer Society Press, Bangalore 2006.

[2] Dave Cavalcanti, Anup Kumar, and Dharma P. Agrawal, "Integrated Heterogeneous Wireless Networks," Chapter 19 in book, Wireless Ad Hoc Networking, pp. 483-503, Auerbach Publications, 2007.

[3] Quan Le-Trung, Gabriele Kotsis "Reducing Problems in Providing Internet Connectivity for Mobile Ad Hoc Networks", Wireless and Mobility 2008, LNCS 5122, pp. 113–127, 2008

[4] C. Perkins, E. Belding-Royer and S. Das, "Ad Hoc on Demand Distance Vector (AODV) Routing Protocol," IETF Internet RFC 3561, July 2003.

[5] Xu, Rui;Li, Weihua, etc. "The Research of Gateway Discovery and Selection Schemes for Connecting of MANET and Internet", Proceedings of 2008 IEEE International Conference on Networking, Sensing and Control, ICNSC

[6] Jin, X., Christian, B. " Wireless Multihop Internet Access: Gateway Discovery, Routing, and Addressing" Proceedings of 3GWireless 2002, San Francisco, CA, USA 2002

[7] Y. Sun, E. M. Belding-Royer, C. E. Perkins, Internet Connectivity for Ad Hoc Mobile Networks, International Journal of Wireless Information Networks special issue on Mobile Ad Hoc Networks (MANETs): Standards, Research, Applications, 2002.

[8] C.Jelger, T.Noel, A.Frey, "Gateway and Address Auto-configuration for IPv6 Ad Hoc Networks", IEFT Internet-Draft, draft-jelger-manet-gateway-autoconf-v6-02.txt, April 2004.

[9] R. Wakikawa, J. T. Malinen, C. E. Perkins, A. Nilsson, A.J. Tuominen, Global Connectivity for IPv6 Mobile Ad Hoc Networks, Internet Engineering Task Force, Internet Draft (Work in Progress), Nov., 2002.

[10] B. Park and W. Lee, "ISMANET: A Secure Routing Protocol using Identity-based Signcryption Scheme for Mobile Ad-hoc Networks," IEICE Transaction on Communications,Vol. E88-B, No. 6, June 2005.

[11] B. Park, W. Lee, C. Lee, J. Hong, and J. Kim, "LAID: Load-Adaptive Internet Gateway Discovery for Ubiquitous Wireless Internet Access Networks," Proceedings of the International Conference on Information Networking (ICOIN) 2006. January 2006.

[12] Mari Carmen Domingo,"Integration of ad hoc networks with fixed networks using an adaptive gateway discovery protocol", Intelligent Environment,2006, Vol: 1, PP 371-379, July 2006.

[13] B. Park and C. Lee, "QoS-aware Internet access schemes for wireless mobile ad hoc networks", Elsevier Computer Communications (COMCOM), Vol.30, No. 2, pp. 369-384, January 2007.