The Gateway based Adaptive Gateway Discovery Scheme in Mobile Ad-hoc Networks

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Abstract— from last two decades wireless networks are gaining popularity and have been widely used. Mobile ad-hoc network is a great solution to the current need of low-cost, on-demand, autonomous and infrastructure-less network which is highly portable, mobile and temporary in nature. To connect MANET to fixed network, any node in MANET should be configured as a gateway. Node that wants connectivity needs to discover present gateways in MANET. To reduce overhead, previous schemes tune Time to Live and/or Advertisement Interval of gateway advertisement packets based on total source nodes and/or mobility of nodes in MANET. As discussed in [4], it is also possible to consider number of gateways in MANET to adapt the discovery procedure. Proposed scheme does the same. It is found that the new scheme shows better results in terms of less routing overhead with same Delivery Ratio and End-to-End Delay, compared to proactive and hybrid gateway discovery schemes.

Keywords— TTL; MN; AODV; NIC; FN; GWADV; RMD.

I. INTRODUCTION

This document is a template. An electronic copy can be downloaded from the Journal website. For questions on paper guidelines, please contact the journal publications committee as indicated on the journal website. Information about final paper submission is available from the conference website Wireless technology is becoming a key technology to connect different mobile devices and networks due to its low cost and flexibility. Mobile ad-hoc networks are special case of wireless networks. These networks are multi-hop wireless networks which are also low cost, autonomous, infrastructure-less and temporary in nature. These unique characteristics make it prevalent research area over the last couple of years.

Figure 1: Simple MANET with Internet Connectivity
As the applications of mobile ad-hoc networks are increasing, there is an increasing demand for connecting MANET to the internet. To connect MANET node (MN) to the internet, node needs to search for the available gateway(s) (see fig. 1) as well as path towards the gateway. Procedure to get this information or make this information available to MN is called “Gateway Discovery”. For gateway discovery, either gateway proactively broadcast its existence to all MNs or the MN who wants connectivity asks for that information reactively. Compromise between above two is hybrid gateway discovery scheme which combines both the previous approaches.

Remaining of the paper is organized as follows: Section 2 includes the architectural issues to connect MANET to the internet, use of AODV protocol for gateway discovery and basic gateway discovery schemes in brief. Section 3 discusses the performance of basic discovery schemes and adaptive gateway discovery schemes in brief. Section 4 describes the proposed approach and section 5 discusses the results. At last section 6 concludes the paper.

II. RELATED WORK

This section considers the general architecture and protocol aspects to connect mobile ad-hoc networks to the internet.

As the architecture described in paper [1], to connect MANET to the internet one of the MN should be configured as a gateway. Gateway is the MN which is less mobile and generally lying at the periphery of MANET and capable of running different protocol stacks on different NICs connected to each interface. Gateway could be single or multiple based on the total number of MNs looking for internet connectivity in MANET. Procedure to either provide or solicit for the information about available gateways in MANET is called “Gateway Discovery”.

As the routing protocol does almost the same task of finding the destination MN in MANET, these protocols are used for the gateway discovery with some modifications. Paper [3] specifies modifications made in AODV (The most widely accepted on-demand routing protocol) to enable it for internet connectivity. To enable AODV for internet connectivity author has added a new flag called I-flag (internet flag) to AODV request packet and reply packet which indicates that message is for gateway discovery only. Procedure is like this, whenever MN wants to communicate with the node in the fixed network it asks for solicitation by sending RREQ_I message to all gateway nodes in the MANET. After receiving solicitation each gateway replies with RREP_I message which includes information about that gateway and path towards that gateway. Node selects the appropriate gateway, adds the routing table entry for the fixed node (FN) and transmits data packets for the fixed node to the selected gateway. So it defines the basic reactive gateway discovery scheme.

Paper [4] explains three basic gateway discovery schemes and evaluates them for different network conditions. Those schemes are proactive, reactive and hybrid. Reactive discovery scheme is same as the above. In proactive gateway discovery scheme, each gateway broadcasts its presence at fixed interval of time by sending GWADV (gateway advertisement) message. At the time of receiving this advertisement message, each MN make the entry for the selected gateway in its routing table and use that information for future communication. Proactive scheme creates unnecessary traffic on the network while provide good connectivity and reactive scheme don’t create unnecessary traffic but not provide always on connectivity. Thus the compromise between these two schemes have been suggested which offer benefit of both the schemes. Hybrid scheme is same as the proactive because it broadcasts the GWADV packet at predefined time interval but up to limited area defined by ADVERTISEMENT_ZONE. Nodes outside this range will solicit for the gateway information reactively. From the analysis it has been found that selection of the discovery scheme depends on different network conditions. Network conditions/parameters include number of source nodes, number of gateways and stability of the network. Performance analysis concludes that not a single scheme is better for all network conditions and thus there is a need for adaptive gateway discovery scheme which adapt itself to different network conditions.

III. ADAPTIVE GATEWAY DISCOVERY SCHEMES

Few adaptive gateway discovery schemes have been found in literature. This section will discuss those in brief.

Paper [5] proposes adaptive hybrid scheme where each gateway does two types of advertisement periodic advertisement and adaptive advertisement. When gateway detects the topology changes by analyzing each control packet going through it, it stores the required information in the data structure. It detects the network changes by calculating the value of RMD (regulated mobility degree) which is ratio of internet joining node to advertisement forwarding (AF) node by using the information available in the table. At a fixed interval, each gateway checks for the value of RMD, if it is above threshold then it does adaptive advertisement otherwise not. Time interval for the periodic advertisement has been set longer. Flooding area can be limited by allowing advertisement forwarding nodes and k non-AF nodes to re-broadcast adaptive advertisement packets. Thus scheme reduces the overhead.

Paper [6] suggests almost same solution as [5] but the difference is in detection method. Procedure to gather the required information is also same here. Each gateway maintains a MN list (MNL) for every MN connected through it. But for detection of the topology changes, rather than calculating RMD value each gateway just looks for the changes in
field value in the list at every fixed interval of time. When gateway detects these changes above threshold, it initiates adaptive advertisement. Flooding area for the next adaptive advertisement should be average of all TTL values in the MNL.

The [7] paper describes analytical model of basic discovery schemes and shows that all basic methods are only suitable for limited range of network parameters. From the analysis, it derives the equation to calculate the value of TTL in such a way that it gives maximum benefit for next advertisement and thus named “Maximal Benefit Coverage”. Equation can be solved by dynamic programming which will dynamically adjust the scope of adaptive advertisement and thus creates less control overhead compared to basic schemes.

Paper [8] combines above three approaches ([5], [6] & [7]). In this paper, adaptive advertisement takes place whenever there is a change in network topology. Topology changes are detected from the RMD (regulated mobility degree) value and advertisement flooding area is calculated by using “maximal benefit coverage”. This complete adaptive scheme shows better results in terms of lesser overhead compared to maximal benefit coverage.

So the ultimate goal of all approaches is to get maximum PDR with minimum overhead & delay.

IV. PROPOSED GATEWAY DISCOVERY SCHEME

All adaptive schemes described above were considering the number of source nodes in MANET to adapt the gateway discovery scheme. Simple rule of thumb is to either modify the value of advertisement interval for proactive discovery scheme or adjust the value of flooding area for reactive discovery scheme whenever it detects change in network parameter. The proposed scheme gives the more enhanced adaptive scheme to tune the advertisement interval as well as flooding area of the advertisement message by considering Number of Gateways in MANET which has not yet been considered. Scheme enhances the performance of gateway discovery procedure by considering neighborhood gateways to the corresponding gateway. Because of the lack of the centralized entity in MANET proposed scheme works on the principle of locality.

Procedure as simple as follows, rather than removing the advertisement massages from the neighbor gateway, each gateway stores that information to take decision for the next advertisement. At the time of gateway advertisement each gateway uses that information to calculate gateways near by it. If the gateway finds more gateways around it, it should advertise less either with lesser flooding area or after a long time interval. As the total number of gateways in the neighborhood increases the value of TTL should decrease and the value of ADVERTISEMENT_INTERVAL should increase. Means with the increase in neighborhood gateways, discovery scheme should adapt itself to more reactive or less proactive method. Change in the value of ADVERTISEMENT_INTERVAL or TTL with the change in the total number of neighbor gateways is again an issue of research.

As far as implementation is concern, we have changed the value of TTL by 5 for proactive discovery scheme and by 1 for hybrid discovery scheme. The difference in tuning the TTL parameter for hybrid discovery scheme is that change of TTL value by 1 is made when each gateway detects two neighborhood gateways rather then one. Value of advertisement interval is decreasing by 0.5 for both discovery schemes with the detection of each new neighborhood gateway.

Proposed scheme works on the principle of locality and removing the unnecessary control traffic generated by each gateway.

V. RESULTS

Each point in the graph is average of 10 simulation runs. As we move horizontally in the graph, each new point gives the value for 2, 4, 6 & 7 numbers of total gateways. With the increase in total numbers of gateways, PDR increases while the overhead and average end-to-end delay decreases because of the higher availability of gateways in the MANET. Same effect can be seen in all the graphs given below as the numbers of gateways are increasing.

By considering the same simulation setup and performance metrics given in the appendix, results shows better performance in terms of lesser overhead with almost same number of delivered packets and same average end to end delay compared to basic proactive and reactive schemes.

Graphs 1-1, 1-2 & 1-3 compare the proposed scheme with the proactive gateway discovery scheme by tuning the value of TTL. Graphs show that PDR and End-to-End delay for the proposed scheme is almost same as the proactive scheme. The difference in PDR is at most 0.51% and difference in End-to-End delay is at most 0.47% which can be acceptable. Overhead for the proposed scheme is decreasing by 9.96% which is considerable cut off in control overhead.
Graphs 2-1, 2-2 & 2-3 compare the proposed scheme with the proactive gateway discovery scheme by tuning the value of ADVERTISEMENT_INTERVAL. Graphs show that PDR and End-to-End delay for the proposed scheme is almost same as the proactive scheme. The difference in PDR is at most 0.46% and difference in End-to-End delay is at most 0.62% which can also be acceptable. Overhead for the proposed scheme is decreasing by 6.21% which is considerable cut off in control overhead.
Graphs 3-1, 3-2 & 3-3 compare the proposed scheme with the hybrid gateway discovery scheme by tuning the value of TTL. Graphs show that PDR and End-to-End delay for the proposed scheme is almost same as the hybrid scheme. The difference in PDR is at most 0.66% and difference in End-to-End delay is at most 0.95% which can be acceptable, if we get more benefits in terms of overhead. Overhead for the proposed scheme is decreasing by 5.60% which is considerable cut off in control overhead.
Graphs 4-1, 4-2 & 4-3 compare the proposed scheme with the hybrid gateway discovery scheme by tuning the value of ADVERTISEMENT_INTERVAL. Graphs show that PDR and End-to-End delay for the proposed scheme is almost same as the hybrid scheme. The difference in PDR is at most 0.54% and difference in End-to-End delay is at most 0.51% which can also be acceptable. Overhead for the proposed scheme is decreasing by 4.12% which is considerable cut off in control overhead.
Graphs show that as the total gateways in MANET increases, we get better results in terms of lesser overhead. The reason for better results is this, as the total number of gateways increases total number of neighborhood gateways also increases which shows more availability of gateways in MANET thus minimizes the need for unwanted advertisements and thus creates lesser overhead without any lost.

VI. CONCLUSIONS

We have implemented proposed gateway discovery scheme in NS-2 and observed the results of 10 simulation runs for each different number of gateways. Simulation results have been compared with the basic proactive and hybrid schemes, we found that proposed scheme generates up to 10% of lesser routing overhead compared to proactive scheme and up to 5% of lesser routing overhead compared to hybrid scheme with almost same PDR and End-to-End delay. So proposed gateway discovery scheme finds better results by considering the total number of neighbor gateways and can be applied to any of the existing adaptive gateway discovery schemes as the extension.

REFERENCES