QOS Parameter Based Performance Study of the Gateway Discovery Approaches for MANET

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ABSTRACT
The gateway discovery in hybrid network is considered as a critical and challenging task and with decreasing pause time and greater number of sources it becomes even more complex. Due to the scarcity of network resources in MANET, the efficient discovery of the gateway becomes a key issue in the design and development of future hybrid networks. In this paper the AODV reactive routing protocol is extended to support the communication between the MANET and the Internet. We have described the design and implementation of the various gateway discovery approaches and carried out a systematic simulation based performance evaluation of them using NS2 under different network scenarios. The performance differentials are analyzed on the basis of two QOS parameters - packet delivery fraction and average end-to-end delay.

General Terms
Emerging Trends in Technology

Keywords
Mobile ad hoc network, Internet, gateway discovery approaches, performance study, packet delivery fraction, average end-to-end delay.

1. INTRODUCTION
The Internet has grown significantly in the current decade to occupy a huge part of the lives of the common people. On the other hand with the huge influx of mobile phones, laptops and personal digital assistants, mobility has become an indispensable part of our daily lives. These devices are highly portable and can be carried anytime anywhere. With the increasing use of these devices there is a growing demand for the connectivity to the Internet while we are on the move. A group of mobile devices can form a self-organized and self-controlled network called a mobile ad hoc network (MANET) [1-5]. The main advantage of these networks is that they do not rely on any established infrastructure or centralized server. But due to the limited transmission range of the MANET nodes, the total area of coverage is often limited. Also due to the lack of connectivity to the fixed network, the users in the MANET work as an isolated group. In order to access the global services from the Internet and to widen the coverage area, there is a growing need to connect these ad hoc networks to the Internet.

Due to the frequent movement of nodes and highly dynamic topology, routing in MANET is considered a highly challenging task. The MANET working group [6] in the Internet Engineering Task Force has proposed several routing protocols for communication within the mobile ad hoc network. But as these protocols are designed mainly to handle the communication only within the ad hoc networks, they need to be modified when we need a mobile device in the MANET to communicate with a host computer on the Internet. For this purpose we need Internet Gateways (IGW). These gateways work as bridges between the different network architectures of MANET and the Internet and they need to understand the protocols of both the mobile ad hoc protocol stack and the TCP/IP protocol suite.

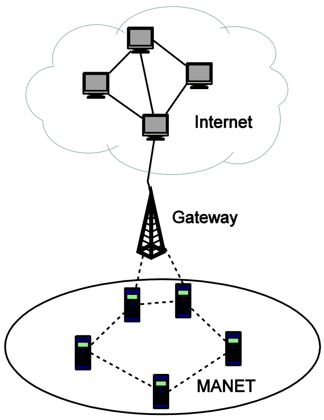

Fig 1: Hybrid Network

The gateway discovery approaches can be broadly classified into three categories- proactive, reactive and hybrid. The gateway itself initiates the proactive [7, 8] gateway discovery by periodically broadcasting the gateway advertisement message to inform the MANET nodes about the global connection information. Reactive [9, 10] discovery is invoked by the mobile node that needs to create a new route or modify the existing route to the gateway. Hybrid [11, 12] approach tries to combine the advantages of both.

Although a lot of research has been done on the mobile ad hoc routing protocols [13], the area of hybrid networking has remained less regarded. In this work we have used the extended AODV reactive routing protocol to support communication between the MANET and the Internet. The basic idea is to use the extended route discovery procedure so that it can be used to find not only the destination mobile node but also to discover the gateway. In this paper we have described the design and implementation of various gateway discovery approaches and studied the performance differentials of these approaches under different scenarios using ns2 based simulation.

The rest of the paper is organized as follows. We investigate the different gateway discovery approaches in section 2. Section 3 and section 4 details the simulation model and the key performance metrics respectively. The simulation results are presented and analyzed in section 5. Finally section 6 concludes the paper and defines topics for future research.

2. GATEWAY DISCOVERY APPROACHES

Depending on who initiates the gateway discovery, these approaches can be broadly classified into the following three categories.

2.1 Proactive Gateway Discovery

The gateway itself starts the proactive gateway discovery by periodically broadcasting the gateway advertisement (GWADV) message. This message is an extended version of the RREP_I message containing the additional RREQ ID field form the RREQ message and is transmitted at regular intervals after the expiration of the gateway's timer (ADVERTISEMENT_INTERVAL). The mobile nodes which are within the transmission range of the gateway, receive the advertisement and either create a new route entry or update the existing route entry for the gateway in their routing table. After this, a mobile node checks to find whether a GWADV message with the same originator IP address and same RREQ ID has already been received within the same time interval. If it is not so then the new advertisement is rebroadcasted, otherwise it is discarded. This solves the problem of duplicated advertisement messages and allows the flooding of the advertisement message through the whole network with controlled congestion.

2.2 Reactive Gateway Discovery

In this approach a mobile node that wants to find a new route or update an existing route to the gateway, initiates the gateway discovery. If a source mobile node wants to communicate with an Internet node, it first performs the expanding ring search technique to find the destination within the ad hoc network. When it obtains no corresponding route reply even after a network-wide search, the source mobile node broadcasts a RREQ_I message to the ALL_MANET_GW_MULTICAST address. This is the IP address for the group of all gateways. Thus only the gateways receive and reply to this message. The intermediate mobile nodes receiving this message simply rebroadcast it after checking the RREQ ID field, to avoid any kind of duplicate broadcast. After receiving the RREQ_I, the gateways unicast back RREP_I message to the source node. The source then selects one of the gateways based on the hop count and forwards the data packet to the selected gateway. Next, the gateway sends the data packet to the destination node in the Internet.

2.3 Hybrid Gateway Discovery

In the hybrid gateway discovery approach the gateway periodically broadcasts the GWADV message. The TTL is set to ADVERTISEMENT_ZONE so that the advertisement message can be forwarded only up to this maximal number of hops through the ad hoc network. The mobile nodes within this region receive this message and act according to the proactive approach. The nodes outside this region discover the default routes to the gateways using the reactive approach.

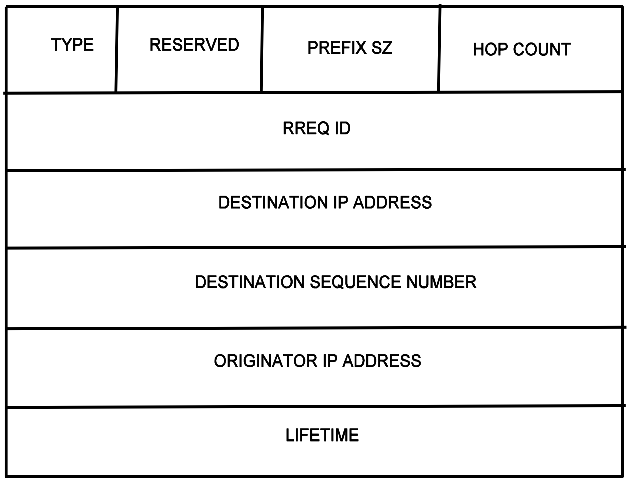

Fig 2: Format of Gateway Advertisement (GWADV) Message

3. SIMULATION MODEL

Table 1: Simulation Parameters

Parameter	Value
Number of Mobile nodes	50
Number of sources	10,20
Number of gateways	2
Number of hosts	2
Transmission range	250 m
Simulation time	900 s
Topology size	1200 m X 800 m
Source type	Constant bit rate
Packet rate	5 packets/sec
Packet size	512 bytes
Pause time	0,100,200,300,400,500, 600,700,800,900 seconds
Maximum speed	20 m/sec
Mobility model	Random way point
Gateway discovery approaches	Proactive, reactive and hybrid

We have done our simulation based on ns-2.34 [14, 15]. Our main goal was to measure the performance of the different gateway discovery approaches under a range of varying network conditions. We have used the Distributed Coordination Function (DCF) of IEEE 802.11[16] for wireless LANs as the MAC layer protocol. DCF uses RTS/CTS frame along with random back off mechanism to resolve the medium contention conflict. As buffering is needed for the data packets which are destined for a particular target node and for which the route discovery process is currently going on, the protocols have a send buffer of 64 packets. In order to prevent indefinite waiting for these data packets, the packets are dropped from the buffers when the waiting time exceeds 30 seconds. The interface queue has the capacity to hold 50 packets and it is maintained as a priority queue. In our simulation environment the MANET nodes use constant bit rate (CBR) traffic sources when they send data to the Internet domain. We have used the cbrgen traffic-scenario generator tool available in NS2 to generate the CBR traffic connections between the nodes. We have used two different communication patterns corresponding to 10 and 20 sources. The complete list of simulation parameters is shown in Table 1.

3.1 Hybrid Scenario

We have used a rectangular simulation area of 1200 m x 800 m. Our mixed scenario consists of a wireless and a wired domain. The simulation was performed with the first scenario of 50 mobile nodes among which 10 are sources, 2 gateways, 2 routers and 2 hosts and the second scenario of 50 mobile nodes among which 20 are sources, 2 gateways, 2 routers and 2 hosts. One of the two hosts in the wired domain is chosen randomly as the required destination for each data session. Each host is connected to the gateway through a router. For our hybrid network environment we have two gateways located at each side of the simulation area and running both extended AODV and fixed IP routing protocols. Their x,y-coordinates in meters are (200, 400) and (1000, 400). The sources start sending data packets after the first 10 seconds of simulation in order to ensure that the data packets are not dropped due to the lack of routes not yet established. They stop sending data packets 5 seconds before the end of the simulation so that the data packets sent late get enough time to reach their destinations.

4. PERFORMANCE METRICS

We have primarily selected the following two parameters in order to study the performance comparison of the three gateway discovery approaches.

Packet delivery fraction: This is defined as the ratio between the number of delivered packets and those generated by the constant bit rate (CBR) traffic sources.

Average end-to-end delay: This is basically defined as the ratio between the summation of the time difference between the packet received time and the packet sent time and the summation of data packets received by all nodes.

5. SIMULATION RESULTS AND ANALYSIS

In this section we have studied the effect of the three gateway discovery approaches under varying pause time and increasing number of sources, on the performance of the hybrid ad hoc network.

5.1 Packet Delivery Fraction (PDF) Comparison

From Figure 3 and Figure 4 we see that the proactive approach has better packet delivery performance than the reactive approach. This happens because - due to the periodic update of route information form the gateway, routes form all the nodes to the gateway are always available. As a result majority of the packets are delivered smoothly. In case of reactive approach, a node wishing to send data to the destination needs to find the route to the gateway first. This takes a certain amount of time and no packet can be sent during this period due to the unavailability of routes.

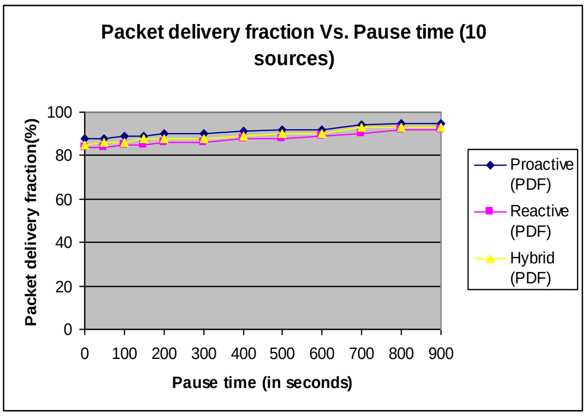

Fig 3: Packet Delivery Fraction Vs. Pause Time for 10 sources

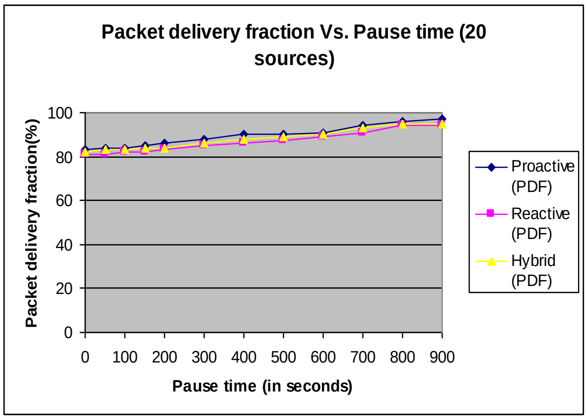

Fig 4: Packet Delivery Fraction Vs. Pause Time for 20 sources

From the figure it is evident that the packet delivery performance deteriorates with decreasing pause time in all three approaches. Due to high mobility and frequent link breaks, nodes won't be able to send data packets to the gateway thereby reducing the packet delivery ratio. In the reactive approach, the routes are not optimized and nodes continue to maintain longer routes. As pause time decreases, the topology becomes highly dynamic. Due to the frequent link breaks, the older routes tend to become stale quickly. But the source node continues to send packets through these stale routes until it receives RERR message from a mobile node having a broken link. With longer routes it takes greater time for the source node to receive RERR. As a result, during this time greater numbers of packets are dropped. From the figure we also see that as the number of sources is increased, initially the packet delivery performance becomes better. This is due to the fact that with less number of sources, the channel capacity is not fully utilized. Therefore, increasing the number of sources also increases the packet delivery ratio. However, when the number of sources is increased more, there will be high volume of traffic in the network leading to congestion. Due to greater control traffic, less portion of the channel is left for the data. This ultimately reduces the packet delivery ratio.

5.2 Average End-to-End Delay Comparison

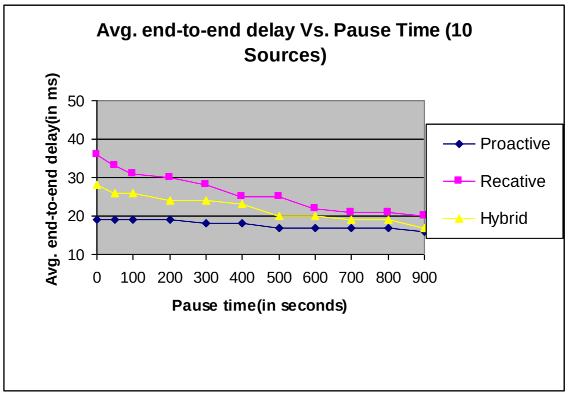

Fig 5: Average End to End Delay Vs. Pause time for 10 Sources

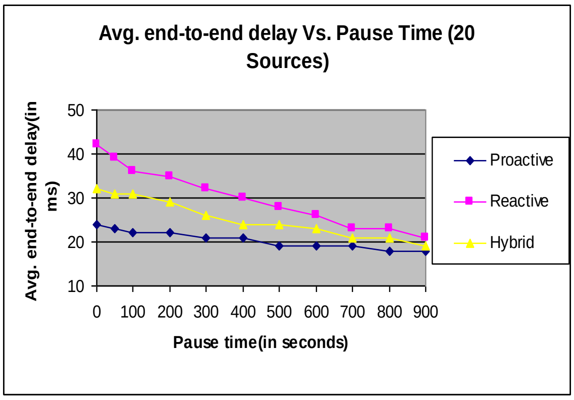

Fig 6: Average End to End Delay Vs. Pause time for 20 Sources

From Figure 5 and Figure 6 we see that the average end-to-end delay with the proactive and hybrid gateway discovery approach is less in comparison to the reactive gateway discovery. In proactive approach, due to periodic route updates from the gateway, routes are optimized regularly and the nodes have fresher and shorter routes to the gateway. Moreover, all the routes are maintained all the time. This instant availability of the fresher and shorter routes enables the nodes to deliver packets to their destinations with less delay. In reactive approach, a node needs to find a route to the gateway first before sending the packet. This initial path setup delays the delivery of the packets.

From the figures we also see that the average end-to-end delay increases with decreasing pause time and increasing number of sources. As the nodes become more mobile, the links break more frequently. This together with the greater number of sources, necessitates the reactive route discovery process to be invoked more often thus causing huge amount of control traffic. The data traffic also increases with more number of sources. This results in more collisions, more retransmissions and further congestion in the network. Consequently the constrained channel increases the route discovery latency which in turn increases the average end-to-end delay. In the absence of any regular route update mechanism, reactive approach suffers from older and longer routes which increase the chances of link breaks, leading to further delay.

In case of hybrid approach, in the simulation done in our work, the gateways broadcast the gateway advertisement messages periodically up to three hops away and the nodes beyond that region follow the reactive gateway discovery approach. As a result the average end-to-end delay becomes less than that of the reactive approach but more than that of the proactive approach.

6. CONCLUSION

In this paper we have carried out a detailed ns2 based simulation to study and analyze the performance differentials of these approaches on the basis of two QOS parameters - packet delivery fraction and average end-to-end delay. From the simulation results we see that the proactive approach shows better packet delivery performance than the reactive approach mainly due to the instant availability of fresher and newer routes to the gateway all the time. With greater number of sources, although initially the packet delivery performance becomes better but later when the number of sources is increased more, due to congestion the packet delivery ratio drops. In terms of the average end-to-end delay, the proactive and hybrid gateway discovery approaches outperform the reactive gateway discovery. As we decrease the pause time and increase the number of sources, all the approaches suffer form greater average end-to-end delay.

In our future work, we plan to study the performance of these gateway discovery approaches under other network scenarios by varying the network size, the number of connections, distance between the gateways, the mobility models and the speed of the mobile nodes etc.

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