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Gateway Load Balancing in Integrated Internet-MANET to Improve Network Performance

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***Abstract*—– The mobile ad hoc networks have become a major component of the future network development due to their ease of deployment, self-configurability, flexibility and independence on any existing network infrastructure. There is a growing need to integrate these ad hoc networks to the Internet. For this purpose we need gateways which act as bridges between these two different protocols architectures. When a Mobile Ad Hoc network (MANET) is connected to the Internet, it is important for mobile nodes to detect available Internet gateway (IGW) providing access to the Internet. Gateway discovery time have strong influence on packet delay and throughput. In most of the cases, a mobile node uses min-hops to the gateway to communicate a fixed host connected to an Internet.**

These dynamic gateways can use Mobile IP and DSDV protocol when they communicate with the internet and interact with MANET. Integrated Internet-MANET is the Interconnection of wired Internet and wireless mobile ad hoc networks that enable to communicate between wired and wireless peers.

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

I.

II. INTRODUCTION

Mobile wireless ad hoc networks [1] usually consist of mobile nodes that are unreachable through a single hop. Therefore, the main focus of ad hoc routing protocols has been to support the wireless multi-hop routing capability. These wireless links usually have lower capacity than wired links. Hence, congestion can be normal phenomenon rather than exception in mobile ad hoc networks. Currently, ad hoc routing protocols lack load-balancing capabilities [2]. Thus, they often fail to provide good service quality especially in the presence of a large volume of traffic since the network load concentrates on some nodes resulting in a highly congested environment. Congestion in this environment causes several undesirable effects such as long packet Latency, poor packet delivery, and high routing overhead [3]. It also causes excessive consumption of the network resources.

We integrate MANET and the Internet into a hybrid network environment. This integration allows MANET nodes, which may be unable to directly access Internet, to share Internet resources. MANET and Internet have many differences. These differences are not only the structure and topology of networks, but also communication protocol of nodes in both networks. In this paper, we first present the dynamic gateway concept that it acts as an interface between MANET and the Internet. These Dynamic gateways can use Mobile IP when they communicate with the internet and DSDV when they interact with MANET, and use the dynamic gateway to solve the load-balancing problem [4].

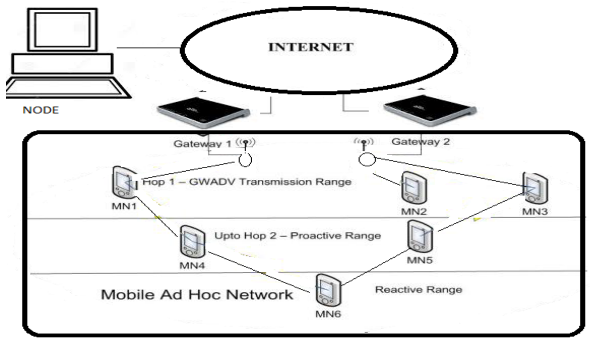

Figure 1. Interconnection between MANET and Internet through Gateway

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.

III. RELATED WORK

Providing Internet connectivity to MANET requires gateways that act as bridges between the MANET and Internet, since the gateway has to understand the Internet protocol (IP)as well as a MANET routing protocol

In [5], **E.M. Belding-Royer** et al. proposed Mobile IP [10], which was supported by IPv4 Ad Hoc networks with AODV routing protocols. The proposed scheme has a proactive agent solicitation procedure with AODV route search to register to Mobile IP. It distinguishes the location of destination nodes using F-RREP of FA, when a packet is sent to the Internet.

Hossam El-Moshrify et al. [6] proposed a solution in which mobile nodes can access the Internet via a stationary gateway node or access point. Three proposed approaches for gateway discovery are implemented and investigated. Also, the effect of the mobile terminals speed and the number of gateways on the network performance are studied and compared.

Hamidian et al. [7] proposed a solution, which provides Internet connectivity to ad hoc Networks by modifying the AODV routing protocol. Three methods of gateway discovery for a mobile node to access the Internet are provided: proactive, reactive and hybrid approach.

Ratanchandani et al. [8] discusses a hybrid gateway discovery approach. AODV and two Mobile IP foreign agents are used to interconnect MANET and the Internet. However, the TTL of the foreign agent's advertisements is limited.

In [9], **Wu** et al. proposed path-selection criteria (correlation factor) and an on-demand multi-path calculation algorithm that can provide load balancing and reduce the frequency of on demand route discovery. Correlation factor metric is used to describe the interference of traffic between two node-disjoint paths.

In [11], **Pham** et al. proposed a Multi-Path Routing with Load Balance (MRP-LB), which

Maintains multiple routes for each source destination pair and spread traffic evenly on to these routes, i.e. the total number of congested packets on each route is equal. In this protocol, data packets are likely to arrive out of order since they are sent on different paths and experience different delays. This protocol consists of two phases, Route Discovery and route Maintenance. After the Route discovery phase, the source node has the current information about the load on each route.

In[12] **, Rakesh** et al. presented analysis of existing load-aware routing protocols for Mobile Ad Hoc network. Based on, a proactive load-aware Internet gateway discovery scheme using a new metric. This Internet gateway discovery scheme is able to mitigate the congestion conditions in Ad Hoc networks for Internet access. Which evaluate protocol performance through simulation for different traffic and mobility conditions.

IV. MANET AND INTERNET CONNECTIVITY

MANET	GATEWAY		INTERNET HOST
APPLICATION	APPLICATION	APPLICATION	APPLICATION
UDP	UDP	UDP	UDP
IP/AODV	IP/AODV	IP	IP
LLC 802.11 MAC	LLC 802.11 MAC	DATA LINK	DATA LINK
802.11 PHY	802.11 PHY	PHYSICAL	PHYSICAL

Figure 2. Protocol Architecture for Interconnection between MANET and Internet

V. GATEWAY DISCOVERY APPROACHES

In gateway discovery approaches, these approaches can be broadly classified into the following three categories.

A. 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[13] field form the RREQ message and is transmitted at regular intervals after the expiration of the gateway's timer (ADVERTISEMENT_INTERVAL)[14]. 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 rebroadcast, 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.

B. 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 [15] 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.

C. Hybrid Gateway Discovery

In the hybrid gateway discovery approach the gateway periodically broadcasts the GWADV message. The TTL is set to ADVERTISEMENT_ZONE [16] 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.

D. Adaptive Gateway Discovery

To offset changing ad hoc network conditions like node density, transmission quality etc; a static TTL value cannot be used. A modified Hybrid Gateway Discovery mechanism which dynamically adjusts value of TTL and periodicity of GW_ADV messages [17] depending on the MANET characteristics in order to achieve a good trade-off between performance and network overhead is called an Adaptive Gateway Discovery Mechanism. Several novel strategies have been proposed recently which implement adaptive gateway discovery mechanisms in different ways.

VI. PROBLEM DOMAIN

Currently there is a plethora of proposals to solve the problems of MANET-INTERNET integration. Many of the designs suffer from complexity and design solutions that have not been properly evaluated. The main issue in MANET-INTERNET integration is the design of internet connectivity for MANETs that can handle node mobility both at micro and macro level that is within the same MANET and between the MANET and another networks, MANET or other fixed wired or wireless networks respectively, having continuous and uninterrupted internet connections whenever there is at least one potential route to one or more gateways.

Three challenging problems in Mobile Ad-hoc network

i) Determine the location of Node
ii) Discovering valuable gateway
iii) Maintain and stabilize the state of Discovered Gateway.

The Major and significant problems based on above scenario discussed that still require to investigate of an efficient and robust network condition independent solution for MANET-INTERNET[4] integration has to be address the following problems:

iv) Control Overheads: Overheads introduced due to the Gateway solicitation, Gateway advertisement and mobile IP itself.
v) Load balancing: Balancing among the different gateways when connected with same/ different nodes.
vi) Multi homing: To maintain the consistent connectivity simultaneously with multiple gateways.
vii) Hand Offs: Switching from one gateway to another when the mobile node roams outside the vicinity of the current gateway i.e. to provide smooth seamless roaming.
viii) Gateway Selection: To select the optimal gateway from the multiple available gateways.

The proposed reactive load balancing requires two steps:

i) Calculate the available bandwidth on each path using the probe packet
ii) Perform the load balancing based on the calculated Available bandwidth on all paths

VII. SIMULATION MODEL AND PERFORMANCE EVALUATION

A. MOVEMENT MODEL: - We used the Random Waypoint Movement Model [18] as the mobility model for our simulation. It is the benchmark mobility model that has been used in many research works in order to evaluate network protocols in MANET. According to this model, a mobile node remains stationary for a certain period called pause time. After the pause time is over the node selects a destination randomly and moves to that destination at a random speed. The random speed is distributed uniformly between zero (zero not included) and some maximum speed. We set the maximum speeds between 2 to 30 m/s for different scenarios.

When the node reaches the destination, it again remains stationary for the pause time period and repeats the same procedure until the end of the simulation. We set the pause time to 20 seconds in our simulations which is good enough for a node to change the movement direction.

B. COMMUNICATION MODEL: - We allowed all the mobile nodes in the network to access the Internet, i.e., each mobile node sends data packets to the hosts in the Internet. Each mobile node in our simulation uses Constant Bit Rate (CBR) traffic to send packets to the corresponding hosts in the Internet. We wish to see the performance of different schemes under heavy traffic load. For this reason, we allow each mobile node to generate 10 packets per second and send them to the Internet. Like we permit each mobile node in the MANET to generate packets of size 512 bytes. By varying the number of nodes, we actually varied the traffic load in different simulation scenarios.

C. PERFORMANCE METRICS: - The metrics which are used to evaluate performance of MANETs routing protocols are as follows:

1. Packet Delivery Fraction: It is defined as the ratio of all received packets at the destinations to all transmitted packets from CBR source. The packet delivery ratio is the fraction of packets that successfully arrive at their destination.
2. Throughput: It is defined as the ratio of data packets received to the destination to those generated by source. Throughput is average rate of packets successfully transferred to their final destination per unit time.
3. End-to-End Delay: It is the average delay time for a data packet travelling from its source to destination. It signifies the amount of time taken by packet from source to destination. The delay time of all successfully received packets is summed, and then the average delay time is calculated.

In our future work we aim to further enhance the performance of modified DSR and study its behavior by collaborating path which can further improve its performance.

D. SIMULATION PERAMETERS: - The connections were designed to simultaneously generate both uplink and downlink traffic between 10 randomly chosen nodes and a generic exterior (Internet) host. For the simulations, all the traffic is transmitted between the mobile node and the Access Router. So, the analysis just computed the packets losses and delays which took place in the hops within the ad hoc network (Internet losses and delays are not modelled).

Table -1 Simulation parameters

Parameter	Value
Platform	Linux CentOS 5
NS Version	Ns-2.33
Mobility Model	Random Way Point
Traffic Type	CBR
Area	500 * 500 m
Experiment Duration	150 sec
MAC Layer Protocol	Mac/802_11
Packet Size	512 bytes
Radio Propagation	TwoRayGround
Packet Interval	0.2 second
Protocols	DSR,AODV, Modified DSR
Antenna Type	OmniAntenna
Packet Size	512 bytes
Pause Time	5, 10, 20, 40, 100
Number of nodes	10, 20, 30, 40, 50
Interface queue	Drop queue/Priqueue
No of mobile node	07
Link layer type	LL

E. RESULT ANALYSIS: -

In order to evaluate the performance of the proposed mechanism, a software module to include mobile multi-gateway support was developed and integrated into the Network Simulator 2 (ns-2). Ns-2 is by far the most extended simulation soft- ware in the studies on ad hoc networking. Similarly, the proposed algorithm for load balancing between the gateways was incorporated to the software. Simulations considered a typical 1500 m x 300 m bi-dimensional space, placing the access router in the center of the area. The ad hoc network was formed by 50 simulated mobile nodes. Two opposite scenarios have been evaluated: one with no pause time (for which the nodes are continuously in motion) and a static scenario (without mobility). In the first scenario, which could represent a typical application in which the mobility of the nodes is determined by human actions (e.g.: laptops during a conference), the movements were based on the popular Modified Random WayPoint model. For our experiments, we considered diverse types of mobility changing the constant velocity of the nodes from 1 m/s (habitual speed of a walking man) to 20 m/s (case of a scenario with motorized vehicles). In the second scenario, which could correspond to a network of fixed sensors, as there is no mobility, the most determining parameter is the node distribution. Up to 10 different random topologies were simulated to estimate the mean net- work performance.

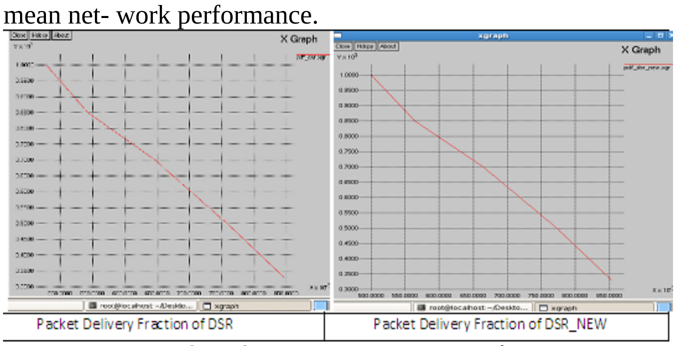

Figure 3: - Packet Delivery Fraction Vs. Pause Time for source

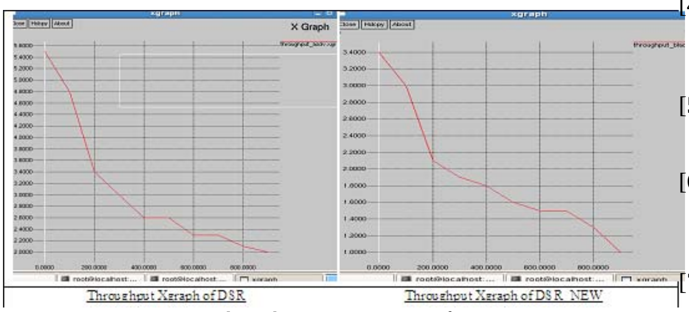

Figure 4: - Throughput Vs. Pause Time for source

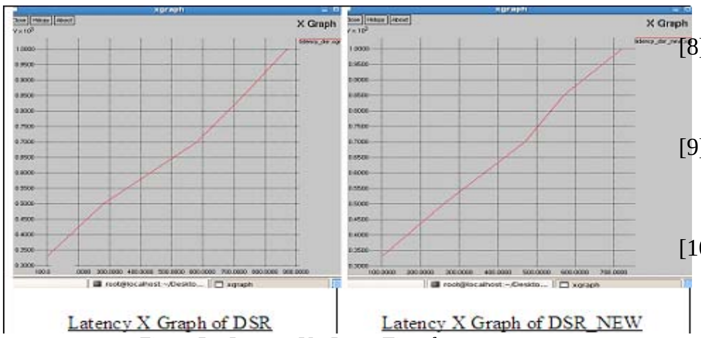

Figure 5: - Latency Vs. Pause Time for source

VIII. CONCLUSION AND FUTURE WORK

In this Paper, we presented novel mechanisms for MANET routing protocols and analyzed the performance of different routing protocol over number of nodes and pause time in the network. Given that maximum load distribution is observed at the center of the network, we proposed load-balancing schemes that push the traffic along the route which is efficient and is having lowest centrality. We also have taken the concept of route rating into account. Therefore, we will choose a path having highest path metric and lowest centrality.

We have proposed a new gateway discovery scheme that is able to mitigate the congestion conditions in an ad hoc network connected to a fixed network. We have run simulations to study which are the optimal values for the configuration parameters (time interval and threshold) of the proposed adaptive gateway discovery mechanism for the selected network conditions. We have shown with the aid of simulations that the proposed adaptive approach outperforms the hybrid scheme in terms of QoS parameters for real-time flows (average end-to-end delay, jitter and packet delivery ratio), without incurring starvation of best-effort traffic. What is more, this adaptive mechanism is scalable with respect to mobility and best-effort traffic load. Thus, we can conclude that the proposed approach is more adequate than the hybrid scheme in heterogeneous networks because it is able to differentiate services between applications, improving the desired quality of service of real-time flows.

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