Pushing the Limits of Multicast in Ad Hoc Networks

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Abstract

This work focuses on the requirements of "better than best effort" (high hop-by-hop delivery guarantee) broadcast in highly dynamic mobile multi-hop ad hoc networks (MANETs). Our work is motivated by mission-critical applications such as disaster relief and military operations. This class of applications is characterized by: (1) high delivery guarantee requirements even in the presence of high mobility, and (2) broadcast-style of communication where all nodes are receivers.

Extensive simulations conducted on two different platforms show that, as node speeds, network traffic load, and number of senders increase, the performance of existing multicast protocols (exemplified by ODMRP and MAODV) degrade in terms of packet delivery and overhead. In contrast, simple flooding, while clearly not a panacea, performs comparatively well and shows promise as a foundation for more specialized protocols for highly dynamic MANETs of the future.

1 Introduction

Mobile multi-hop ad hoc networks, or MANETs, are characterized by the lack of any fixed network infrastructure. All network components of a MANET can be mobile. Moreover, there is no real distinction between a host and a router since all nodes can be sources as well as forwarders of traffic.

A number of MANET-oriented multicast routing protocols have been recently proposed. They can be grouped into two main categories: proactive and reactive. Protocols of the former variety maintain routing state, while the latter reduce the impact of frequent topology changes due to mobility by acquiring routes on demand.

2 Focus

The focus of our work is to probe the need for new protocols that: (1) specifically target broadcast in highly dynamic MANETs and (2) can provide high delivery guarantees. In particular this paper compares the performance of mesh-based and tree-based multicast protocols with plain flooding. The On-Demand Multicast Routing Protocol (ODMRP) [1] was chosen to represent mesh-based protocols . Multicast Ad hoc On-Demand Distance Vector (MAODV) [3] was chosen to represent tree-based protocols. Both protocols belong to the reactive category.

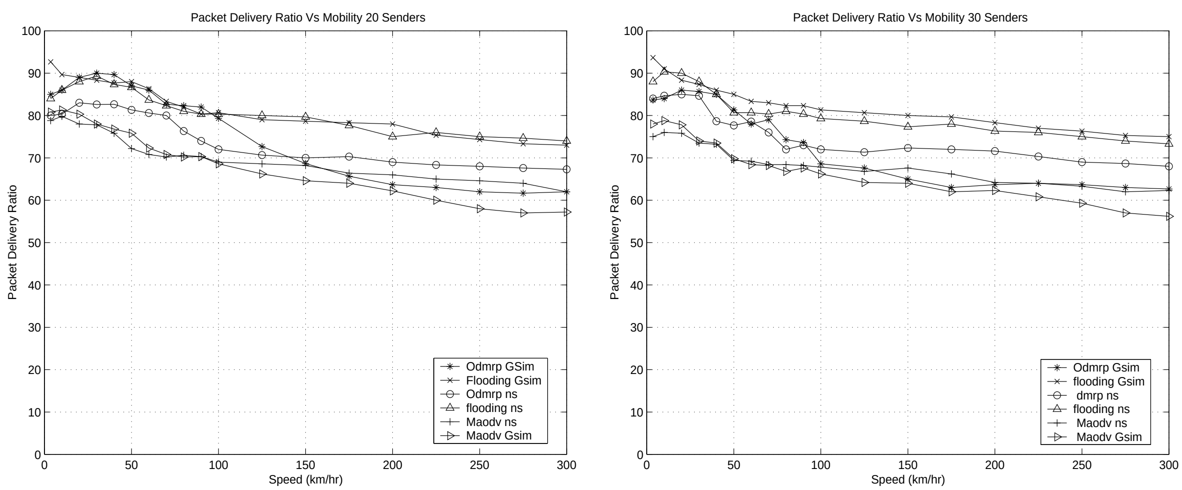
We have used two simulators (`ns`) [2], and GloMoSim [4]. to study the reliability of the different protocols under a wide range of mobility conditions, traffic source populations, and network traffic loads. Although we are mainly interested in how multicast protocols perform in broadcast communication, we also evaluate them for different multicast scenarios.

3 Simulation Environment

In our experiments we used GloMoSim 1.1.1 and ns 2.1b6. we tried to make the two simulation environments equivalent to one another by driving both simulators with the same set of parameters. The total simulation time for both simulators was set to 500 seconds. A total of 50 nodes were randomly placed in a 1000x1000 meter field. Each sender generated 100 packets using a 2 Mbit/sec channel with a power range of 225 meters. The mobility model used is a modified version of the random-waypoint model also known as the bouncing ball model. A constant bit rate (CBR) traffic generator was used for both simulators.

4 Results

We compute packet delivery ratio as the ratio of total number of packets received by the nodes to the total number of packets transmitted times the number of receivers. The graphs in Figure 1 show how protocol reliability varies with mobility (node speed) and the number of traffic sources.



(a) 20 senders

(b) 30 senders

Figure 1: Packet delivery ratio as a function of node speed and number of senders.

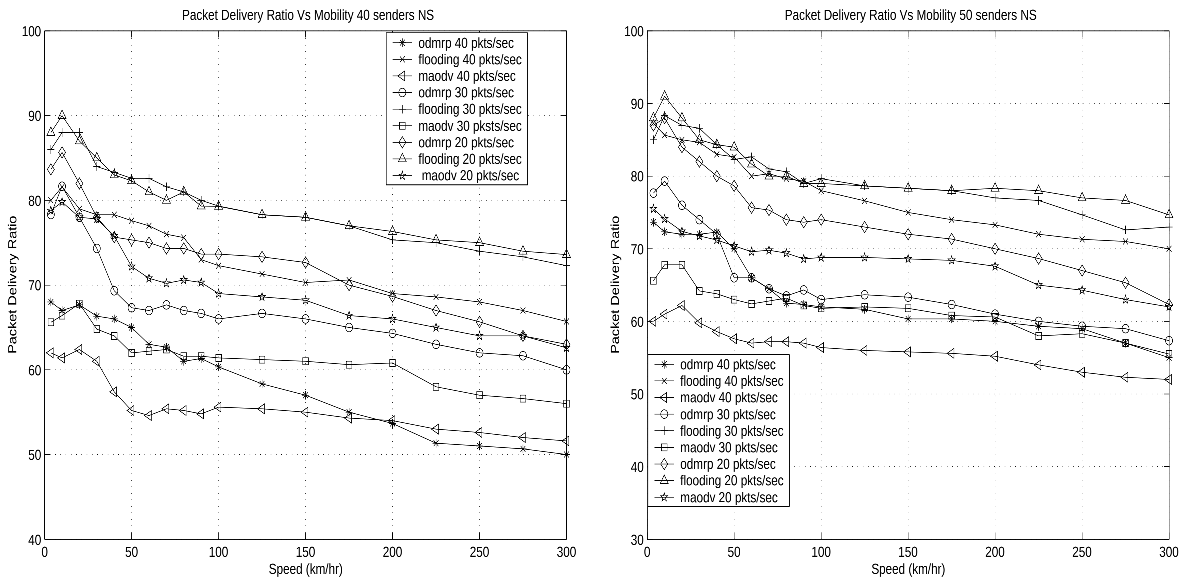
The general trend we observe from both simulators is that for scenarios with moderate ratios between number of senders and number of receivers, flooding performs better than ODMRP which in turn performs better than MAODV.

Parameter	Value	Description
number-of-nodes	50	network nodes
num-packets	100	messages sent by a node
field-range-x	1000 m	X-dimension of motion
field-range-y	1000 m	Y-dimension of motion
propagation-func	FREE-SPACE	propagation function
mac-protocol	CSMA (GloMoSim) 802.11 (ns)	MAC layer
transport-protocol	UDP protocol	transport layer

Table 1: Simulation Parameters.

Network Traffic Load

The goal of this next set of experiments is to evaluate the behavior of both protocols for different network traffic loads.



(a) 40 senders - ns

(b) 50 senders - ns

Figure 2: Packet delivery ratio as a function of network traffic load and node speed for 40 and 50 senders.

Note that all protocols present lower delivery ratio in the 40-sender case. This is because, for the same traffic load with lower number of senders, the inter-packet interval is smaller and thus the chance of losses due to collisions is higher.

We observe that for both 40 and 50 senders and as the traffic load increases flooding maintains higher delivery ratio than ODMRP and MAODV. Take the 50-sender, 40 pkt/sec case: at 0 speed, flooding's delivery ratio is approximately 85%,ODMRP's is 75% and MAODV's is 60% (referring to results from ns simulations); flooding delivers about 68% of the packets at 300 km/h, while ODMRP 55% and MAODV 52%.

5 Conclusions, Ongoing, and Future Work

In summary, this paper reported on simulation-driven experiments evaluating three approaches to broadcast and multicast communication with an emphasis on high delivery guarantees in highly dynamic mobile ad hoc networks. The results demonstrate that as both network traffic load and numbers of senders increase, multicast protocols (exemplified by ODMRP and MAODV) degrade in terms of delivery ratios and overhead. Whereas, plain flooding performs relatively well and shows promise as a foundation for more specialized protocols for highly dynamic MANETs of the future.

References

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