The Effect of Routing Protocol Dynamics on TCP Performance in Mobile Ad Hoc Networks

C. Mbarushimana, A. Shahrabi, and H. Larijani

School of Computing and Mathematical Sciences
Glasgow Caledonian University
Glasgow G4 0BA, U.K.
{Consolee.Mbarushimana,A.Shahrabi,H.Larijani}@gcal.ac.uk

Abstract. TCP, the transport protocol used to carry the major portion of the internet traffic, performs poorly in Mobile Ad Hoc Networks (MANETs) as broadly reported in the literature. This is mainly due to the interactions between TCP and lower layers protocols. Among these, routing protocols have perhaps the greatest impact on the performance of TCP. In this paper, by extensive simulation, we evaluate how TCP interacts with some of the IETF standardised reactive (AODV, DSR) and proactive (OLSR) routing protocols under varying network conditions such as load, size and mobility. In contrast to most of previously reported studies, which have relied solely on TCP traffic, we consider a more realistic traffic carrying a mixture of Constant Bit Rate (CBR) and TCP. We also show how appropriate tuning of route expiry parameters in reactive protocols can improves TCP performance considerably while still generating less routing overhead.

Keywords: TCP, MANET, Routing Protocol, Performance.

1 Introduction

MANETs are future wireless networks consisting of nodes that communicate in the absence of any centralized support. Nodes in these networks both generate user and application traffic and carry out network control and routing duties. The poor performance of TCP in MANETs is attributed to the fact that it is unable to differentiate packet loss due to congestion and unavailability of routes, the later being the most common in MANETs. This calls for a routing protocol capable of constantly presenting valid routes to TCP. Routing protocols in MANETs has received wide interest in the past due to the fact that existing internet routing protocols were designed to support fixed infrastructure and their properties are unsuitable for MANETs. The current standardised protocols are classified into reactive (AODV [12], DSR [8]), and proactive protocols (OLSR [4], DSDV [11]).

Over the past few years, some studies [3], [5], [6] have been reported to evaluate the performance of the proposed routing algorithms. A detailed packet simulation using CBR traffic was reported in [3], and it was shown that DSR and AODV achieve good performance at all mobility rates and speeds whereas DSDV and TORA perform

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poorly under high speeds and high loads conditions respectively. In contrast to this study, Das *et al.* [6] conducted a performance evaluation of more routing protocols and showed that proactive protocols have the best delay and packets delivery fraction but at the cost of higher routing load. In [7] three routing protocols (AODV, DSR and FSR) were evaluated in a city traffic and it was shown that AODV outperforms both DSR and the proactive protocol FSR.

In some other studies, TCP performance was assessed over different routing protocols. Ahuja *et al.* [1] conducted a simulation study of TCP performance over DSR, AODV, DSDV and SSA; however limited conditions were used as the study was conducted with a single TCP connection. A similar study was conducted using TCP Vegas in [10] with reactive protocols outperforming DSDV over a single FTP connection. Different results were presented by Boppana *et al.* [2] who compared the performance of TCP over adaptive proactive (ADV) protocol, AODV and DSR. A limited simulation study of AODV, DSR and OLSR was conducted in [5] and it was shown that OLSR outperforms AODV and DSR by varying the number of TCP connections. Similarly, OLSR outperforms AODV irrespective of the TCP variation by varying the speed in the study conducted in [9].

The proactive protocols used in the above studies were not given further attention by IETF. Instead, IETF has standardised TBRPF and OLSR as proactive routing protocols. Since then, little work has been done to evaluate how the standardised proactive protocols interact with TCP compared to reactive routing protocols. Furthermore, the above named studies used either CBR or TCP; but although multimedia traffic has increased over the past few years, TCP still accounts for more than 90% of the internet traffic. It is therefore crucial to find a routing protocol that performs fairly well in networks where both TCP and UDP traffics coexist. In this paper, by means of OPNET simulations, we conduct a study to evaluate the performance of TCP over AODV, DSR and OLSR, while considering a mixture of TCP and UDP traffic, by varying the network load, network size and the speed of nodes. In addition, the different parameters used by the protocols play an important role in their performances [13]. This paper demonstrates how appropriate tuning of cache parameters in AODV can yield better results in routing TCP traffic while generating less routing overhead than OLSR.

Section 2 of this paper describes the protocols used in this study; section 3 presents the simulation environment, while the results and analysis are presented in section 4. Finally, some concluding remarks are given in section 5.

2 Routing Protocols and TCP Variant Used in the Study

2.1 Ad Hoc On-Demand Distance Vector Protocol (AODV)

AODV minimizes the number of broadcasts by creating routes on-demand. A route request packet (RREQ) is broadcasted by the source till it reaches an intermediate node that has recent route information about the destination or till it reaches the destination. When a node forwards a RREQ to its neighbours, it also records in its tables the node from which the first copy of the request came. This information is used to construct the reverse path for the route reply packet (RREP). AODV uses only