Towards Reliable Broadcast in *ad hoc* Networks

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Abstract—This letter presents new results obtained with a novel MAC scheme designed to be reliable and maximize the throughput of a single-hop network. Contrarily to the IEEE 802.11 MAC scheme, all nodes adopt a common optimal contention window size for unicast and broadcast transmissions, which is based on a common view of the channel. In this way, the conditional collision probability is independent of the type of traffic (broadcast or unicast). Simulation results for different amounts of broadcast/unicast traffic indicate that our approach significantly outperforms IEEE 802.11, exhibiting broadcast aggregate throughput gains up to 40%. Moreover, the simulation results indicate that the probability of successful transmitting a broadcast frame can be also improved up to 50% and, as the number of nodes increase, broadcast frames can obtain approximately the same reliability and throughput achieved by IEEE 802.11 unicast frames.

Index Terms—Reliability, MAC optimization, MAC performance evaluation, broadcast/unicast traffic.

I. INTRODUCTION

CURRENT applications and services for distributed wireless networks heavily rely on advertisements, which are transmitted using broadcast frames [1]. In the current MAC (Medium Access Control) schemes, namely in IEEE 802.11 [2], broadcast co-exists with unicast frames. The unicast traffic is used for point-to-point communications and since retransmissions are allowed, it is highly reliable. The broadcast traffic is used for point-to-multipoint communications and because the destination nodes are unknown, the frames are not acknowledged nor retransmitted, and the transmission scheme is generally unreliable. The reliability concept used in this work is directly expressed by the probability of a successful frame transmission given that one or more transmission attempts have occurred.

Although broadcast traffic is very important for *ad hoc* networks, the most used broadcast MAC schemes for decentralized networks are not reliable, as is observed in [3] for 1-hop IEEE 802.11 networks. Several improvements have been proposed to overcome the low reliability of IEEE 802.11's broadcast transmission scheme, such as the ones presented in [4]–[8]. For all these schemes the decisions made during the protocol's operation are based on the information contained in

a table of 1-hop neighbors. [4] selects one neighbor from that table, which will receive a RTS (Request-To-Send) indicating the subsequent broadcast frame transmission. The nodes that erroneously do not receive the broadcast frame will see higher frame sequences transmitted by the same transmitter. When this occurs they force the failed broadcast frame retransmission by sending a CTS (Clear-To-Send) message with the required sequence number. [5] avoids the collision of CTS frames by transmitting them at different times. [6] solves the same problem by using a leader node that centralizes the CTS transmission. [7] divides the DIFS (Distributed Inter-Frame Space) time in several slots that are used as contention slots to send ACKs to confirm the broadcast frame reception. [8] considers the use of dual tones. [9] proposes BPBT (Broadcast Protocol with Busy Tone), which employs the use of a busy tone to solve a relaxed solution of the excessive retransmission problem. Note that although the schemes proposed in [4]–[9] effectively improve the broadcast reliability, they underperform in terms of throughput, due to the increase of control traffic associated to broadcast transmissions (RTS, CTS or ACKs frames) and the retransmissions of broadcast frames. Recently, other MAC schemes were proposed to improve the reliability of the Layer 2 for specific features of the physical layer, such as the use of network coding [10], and/or new paradigms at the network layer, such as cooperation [11].

This letter presents an extension of the MAC scheme proposed in our work [12] for single-hop decentralized wireless networks. While our previous work describes the design of the MAC scheme and compares its performance with other protocols, it only considers unicast frame transmissions and does not characterize the reliability of the protocol. In this work we summarize the features developed to support both unicast and broadcast traffic and we analyze the reliability of the protocol, by considering the existence of both reliable and unreliable frame transmission schemes (unicast and broadcast transmission schemes, respectively). We evaluate the reliability of the scheme through several simulation results for different quantities of broadcast/unicast traffic. The results show that our approach significantly outperforms IEEE 802.11 in terms of reliability and throughput.

II. NOVEL MAC PROTOCOL

This section briefly introduces the MAC scheme proposed in [12] and explains the rationale behind it. Finally, we enumerate the new features considered in this work in order to support both unicast and broadcast traffic.

A. Brief overview of [12]

Contrarily to IEEE 802.11, which adopts several contention stages regulated by the exponential backoff mechanism, the

Manuscript received September 24, 2011. The associate editor coordinating the review of this letter and approving it for publication was C. Assi.

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This work was partially supported by the Portuguese Science and Technology Foundation under the projects OPPORTUNISTIC-CR PTDC/EEA-TEL/115981/2009, MPSAT PTDC/EEA-TEL/099074/2008 and plurianual projects PEst-OE/EEI/LA0008/2011 and PEst-OE/EEI/UI0066/2011.

Digital Object Identifier 10.1109/LCOMM.2012.010512.111998