Journal of Network and Computer Applications 39 (2014) 126–139

Contents lists available at ScienceDirect

Journal of Network and Computer Applications

journal homepage: www.elsevier.com/locate/jnca

Rate adaptation scheme for IEEE 802.11-based MANETs

Abderrahim Benslimane [a], Abderrezak Rachedi [b,*]

[a] University of Avignon, Computer Science Laboratory of Avignon (LIA), 84911 Avignon cedex 9, France
[b] University of Paris-Est, Gaspard Monge Computer Science Laboratory (LIGM-UMR 8049), 77454 Marne-la-Vallée, France

ARTICLE INFO

Article history:
Received 8 April 2013
Received in revised form
24 April 2013
Accepted 31 May 2013
Available online 13 June 2013

Keywords:
MANET
IEEE 802.11
DCF
Fairness
Throughput and Markov Chain

ABSTRACT

Rate adaptation is a highly challenging task in MANETs, mainly when relative fairness among competitive nodes is considered. Existing rate adaptation solutions are mainly designed for IEEE802.11-based WLANs. They do not cope with relative fairness. Unlike these existing schemes, the main objectives of our proposed approach, called REFOT (Relative Fairness and Optimized Throughput), are to ensure fairness and to allow each node to adapt its transmission rate and contention window to its channel quality. The channel quality is determined by calculating for each node the probability to access the channel in a distributed manner by approximating the number of successful and failed transmissions. REFOT allows for reaching the appropriate transmission rate level, without crossing all the intermediate levels. This operation helps in avoiding scenarios where the network capacity could be underutilized or overused, allowing the system to reach its stability faster. We validate the proposed model via analytical model, based on a 3-dimensional Markov chain and simulation results. Via extensive simulations, the performance of REFOT is evaluated and compared against that of some existing schemes. In the performance evaluation, different node densities, mobility models, transmission ranges and network TCP/UDP traffic loads are simulated. The obtained simulation results are encouraging and indicate that REFOT achieves its design goals: it ensures a good trade-off between fairness and throughput.

© 2013 Elsevier Ltd. All rights reserved.

1. Introduction

The IEEE 802.11 technology implements different Medium Access Control (MAC) methods for both centralized (e.g., wireless LAN) and ad hoc networks. The Distributed Coordination Function (DCF) is the fundamental MAC technique of (IEEE802.11, 1999). It is based on the Carrier-Sense Multiple Access and Collision Avoidance (CSMA/CA) scheme. IEEE 802.11 provides various transmission rates. For instance, in IEEE 802.11a, discrete rates are available ranging from 6 Mbps to 54 Mbps, whereas in IEEE 802.11b, four transmission rates are available (i.e., {1,2,5.5,11} Mbps). Although we have various transmission rates available in IEEE 802.11, there is no standard approach defined to select the appropriate rate while ensuring fairness among the competing nodes. Indeed, fairness and throughput optimization have never been jointly addressed. With this regard, it should be noted that without ensuring an acceptable level of fairness, the whole network becomes unable to reach its optimum cooperative status.

In the recent literature, various rate adaptation schemes have been proposed for WLAN networks. Auto rate fallback (ARF) (Xi et al., 2006) and Collision-Aware Rate Adaptation (CARA) (Kim et al., 2006) are a few notable examples. However, these schemes are not applicable, in their current format, to Mobile Ad hoc Networks (MANETs). Effectively, unlike WLAN which acquires a centralized control unit, MANET networks lack such unit, which renders the fairness issue an important challenge in case of MANETs. As a matter of fact, a MANET node cannot adapt its rate without taking into account the other competitive nodes. Moreover, competing nodes do not necessarily have the same channel conditions. They may, therefore, experience different channel qualities. If a given node does not take into account its competitive neighbors in its rate adaptation operation, an unfair situation is likely to occur.

IEEE 802.11 standard does not take into account the fairness in the context of MANET. Although the standard presents various transmission rates, it does not specify how to efficiently allocate these rates. Generally speaking, the effectiveness of a rate adaptation scheme hinges on how it is coping with the impact of transmission failures which may occur due to channel errors or packet collisions. In the literature, a wide set of rate adaptation schemes have been proposed (Chevillat et al., 2003; Xi et al., 2006; Holland et al., 2001; Kamerman and Monteban, 1997). Unfortunately, none of them is applicable to MANETs. The Receiver-Based Auto Rate (RBAR) scheme (Holland et al., 2001) is based on SNR values whereby a receiver chooses the next rate for its

* Corresponding author. Tel.: +33 160 95 77 37.
E-mail addresses: abderrahim.benslimane@univ-avignon.fr (A. Benslimane), rachedi@univ-mlv.fr (A. Rachedi).

1084-8045/$ - see front matter © 2013 Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.jnca.2013.05.013

corresponding sender. However, the receiver may not have a correct interpretation of the sender channel and other competitive nodes of the sender. Hence, it does not take into account fairness among competing nodes. In another scheme, called Automatic Rate Fall-back (ARF) (Xi et al., 2006), a sender deduces the channel condition by measuring consecutive successful and failed transmissions. The sender then adjusts its rate in accordance with them. However, the drawback of this scheme is that the sender does not care about other competing nodes and adapts its rate without taking them into account. Despite its wide usage in WLAN, ARF is thus not appropriate for MANETs whereby ensuring fairness among active nodes is an important requirement. The CARA scheme is a rate adaptation mechanism with abilities to distinguish between transmission failures due to channel errors and those due to collisions. The key idea behind CARA consists in the fact that a CARA sender decrements its rate after some consecutive transmission failures due to channel errors and increases its rate after some successful consecutive transmissions. In some cases, CARA largely improves the overall throughput, in comparison to the earlier-mentioned schemes. However, the CARA scheme does not take into account other competing nodes either, and therefore does not ensure system fairness. As we will show in the related work section, most, if not all, existing schemes do not jointly consider fairness, throughput efficiency, and transmission rate adaptation in MANET. Some consider only fairness; others consider only rate adaptation, while few methods consider both but in WLAN and not MANET. In Wong et al. (2010), the authors propose airtime fairness in a rate separation IEEE 802.11b WLAN MAC. They group stations according to their transmission rates in different transmission periods. A superframe is decomposed into four parts corresponding to the four transmission rates. Each part is constituted of a beacon period and a data transmission period. An analytical formulation of the saturated throughput is presented. The simulation results show that the proposed rate separation gives advantages of airtime fairness and high saturation throughput. However, the introduction of super frame implies strong synchronization with the access point which coordinates and informs which stations, using the same data rate, can transmit in the following data transmission period. Moreover, this method cannot be applied in MANET, the network type REFOT is targeting.

1.1. Contribution

Classical REFOT (Relative Fairness and Optimized Throughput) is a new mechanism that increases the overall throughput via rate adaptation while maintaining fairness among nodes (Benslimane et al., 2008). According to their access probability, nodes, competing for a particular channel, update their initial contention window size. Adjusting contention window and adapting the transmission rate shall enable nodes to have a certain fairness related to their perceived channel quality without compromising the system throughput.

In this paper, we propose an enhanced and extended version of our legacy REFOT mechanism (Benslimane et al., 2008). The most significant added value consists in (i) the modeling of REFOT using a 3-dimensional Markov chain, (ii) the introduction of an analytical performance evaluation that assists in the optimal tuning of the parameters of REFOT, (iii) and the introduction of a new MAC algorithm considering all improvements following the analytical analysis. In REFOT, we assess the quality of a channel using information on transmission failures and successes. Based on this assessment of the channel quality, a tradeoff is to be retrieved between throughput and fairness. In general, nodes, competing for a particular channel, have access to the channel under different conditions, characterized by different parameters, such as nodes' mobility, nodes' density, traffic intensity, etc. In the modeling of REFOT, we take into account the channel quality which is evaluated by the transmitter before it selects its rate. Then, each node calculates its probability to access the channel while taking into account all its competing nodes. The transmitting node frequently updates this probability each time it desires to send data. REFOT allows for reaching the appropriate transmission rate level, without crossing all the intermediate levels. This operation helps in avoiding scenarios where the network capacity could be underutilized or overused, allowing the system to reach its stability faster.

We further optimize our model using an analytical evaluation and validate it using the Network Simulator (NS-2) (Berkeley and ISI, 1999). In the performance evaluation, we consider different scenarios (i.e., by varying nodes' mobility, nodes' density and traffic intensity). The obtained results show that the new REFOT scheme outperforms its legacy counter part (Benslimane et al., 2008), the CARA scheme (Kim et al., 2006) and the classical DCF scheme (without any rate adaptation) (IEEE802.11, 1999).

1.2. Organization

The remainder of this paper is organized as follows. In Section 2, we introduce the DCF mode of IEEE 802.11 and describe the RTS (Request-To-Send)/CTS (Clear-To-Send) mechanism. We also present existing rate adaptation schemes that are based on IEEE 802.11 standards. Section 3 describes our proposed analytical model. Section 4 presents our proposed REFOT modeling using the three dimensions of Markov chain model. In Section 6, we show the simulation results and discuss them. Finally, Section 7 concludes the paper.

2. Related work

2.1. Preliminaries

In this subsection, we briefly introduce the Distributed Coordination Function (DCF) of IEEE 802.11 standard and the RTS (Request-To-Send)/CTS (Clear-To-Send) mechanism.

2.1.1. IEEE 802.11 DCF

The Distributed Coordination Function (DCF) mode combines Carrier Sense Multiple Access/Collision Avoidance (CSMA/CA) with the Request to Send/Clear to Send (RTS/CTS) handshake to avoid collisions (IEEE802.11, 1999). When a node wants to transmit a packet, it first checks the channel status: if the medium is idle for a period of time longer than or equal to a Distributed Inter Frame Space (DIFS), the packet transmission begins in the following slot. Otherwise, the node should backoff for a certain period based on a value randomly selected from [0,CW], where *CW* denotes the contention window size. The backoff value *CW* is initially randomly selected from within the range $[0, CW_{min}]$, where ($CW_{min}=31$). If the transmitted packet fails, due to collisions or Cyclic redundancy check (CRC) errors, *CW* is doubled. *CW* keeps on increasing until it reaches the upper bound CWmax, where ($CW_{max} = 2^{i_{max}}-1$), where i_{max} is the maximum retransmission number. When the transmission is successful, *CW* is reset to CW_{min}. Although DCF has a random backoff, it still cannot ensure collision-free transmissions, because it is possible that two or more nodes simultaneously finish the backoff. However, the collisions are not the only cause of transmission failures. Channel errors may also cause such failures. In this paper, we introduce the probability of channel access during the backoff time in order to reduce the number of transmission failures due to collisions or channel errors, and to ensure a relative fairness among the different competing nodes.

Download English Version:

https://daneshyari.com/en/article/459638

Download Persian Version:

https://daneshyari.com/article/459638

Daneshyari.com