WLAN Dense Scenarios: a CSMA/CA Enhancement to Improve MAC Layer Efficiency

Extended Abstract

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ABSTRACT

The ever-increasing utilization of the Internet and, especially, the wireless technologies, in everyday use, has led the scientific community to research more ways to deploy better and faster wireless accesses and connections. In fact, this turns to be of crucial importance, particularly in dense wireless networks, where the huge number of users may see their quality of experience severely degraded. Thus, the quality of service is more demanding than ever, in a world where reliable connectivity and fast communications are more and more important. Hence, this work presents a new variant to the popular CSMA/CA (Carrier Sense Multiple Access/Collision Avoidance) MAC layer protocol, named CSMA/CA-DB, where DB stands for "Deterministic Backoff". More precisely, for STAs with packets to transmit, this variant seeks to exploit the use of a deterministic backoff value, in the contention window period, instead of the standard random exponential backoff value, currently in use.

KEYWORDS

WLAN, IEEE 802.11ax, MAC layer efficiency, CSMA/CA, CSMA/CA-DB, deterministic backoff, dense scenarios.

1 INTRODUCTION

The IEEE 802.11 wireless LAN standard, and its amendments, constitute the basis for essentially all the local wireless Internet connectivity throughout the world. The other important form of wireless connectivity is the use of cellular mobile networks. The current demand, though, insists continually in more throughput to the end user, due to the ever-increasing number of users and the kind of applications emerging, especially those involving multimedia data.

The ongoing development of future IEEE 802.11ax wireless LAN standard (with expected publication in 2019) allows a window of time for a study regarding the possible enhancements that can be applied to the current wireless LAN standards. Several enhancements have been proposed in the scientific community, which can be listed as [1]:

1. Spatial reuse;
2. Temporal efficiency;
3. Spectrum sharing;
4. Multiple-antenna technologies.

Concerning the temporal efficiency, one important enhancement is the inclusion of collision-free MAC protocols. Some examples found on the literature are the CSMA/ECA, CSMA–Enhanced Collision Avoidance [2–3], and the CSMA/CDA, CSMA–Collision Detection and Avoidance [4].

2 PROBLEM

Dense wireless LAN scenarios raise several problems nowadays, firstly, because these are more and more common scenarios and secondly, because higher throughput rates are demanded, which requires a better management at the MAC layer.

With present standards, there are interference issues, which imply an increased packet error rate and a reduced number of simultaneous transmissions, since the neighboring WLANs are prevented from accessing the channel. More stations (STAs) will have their backoff counter reaching zero at the same time, hence increasing the number of packet collisions.

The current WLANs adopt the IFS (Inter Frame Space), backoff contention windows and beacons to control the MAC layer. In a dense scenario, these collision avoidance mechanisms are not ideal for several reasons [5]:

1. CSMA/CA chooses a low initial value for the backoff window, due to an optimistic idea that there is a low level of congestion on the network. This means CSMA/CA is not programmed by default for dense scenarios;
2. CSMA/CA can lead to a "fairness problem" because of its binary exponential backoff algorithm, which favors an STA having the last successful transmission. This can lead to a degree of starvation, where certain STAs will have a huge amount of time to wait between transmissions;
3. Contention window control mechanisms are quite complex to implement;
4. RTS/CTS packets, which intend to solve the "hidden node" problem cause an overhead.

3 PROPOSED SOLUTION

The new proposed protocol focuses on a deterministic backoff generated by the AP and sent to the STA on each ACK frame, after each successful transmission. Thus, the new proposed protocol is named CSMA/CA-DB.

The CSMA/CA-DB protocol follows the current medium access protocol on the first transmission attempt by an STA, implementing then a few changes in order to improve efficiency, translating this efficiency gain into throughput enhancements for STAs and APs in an infrastructure network.

Once an STA has access to the channel, it can begin the new algorithm for sending and receiving packets. One first change, compared with CSMA/CA, is the fact that the ACK frame will have one extra byte, containing an integer number corresponding to the next backoff number for this STA. This extra field corresponds then to the number of time slots that the STA should wait before transmitting the next DATA frame. This extra field will be included on each ACK frame before the CRC field, as shown in Fig. 1.

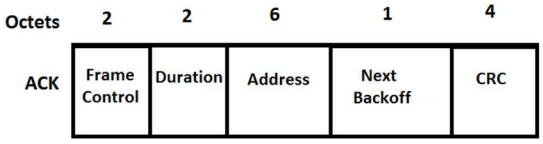

Figure 1: New ACK frame format.

This represents an increase of complexity both for the AP and for the STA. The AP keeps a "scheduling table" with information about the WLAN cell, in terms of next data frames expected to be sent by a certain STA, after a certain number of time slots, and each STA has to read its next backoff number, which is included on the ACK. This mechanism will avoid collisions since the backoff value is no longer randomly determined. When the AP selects a backoff number for a certain STA, the only chance for a collision is in the case the first packet to be transmitted by two STAs have the respective binary exponential backoff values reaching zero at the same time. Another collision possibility is when other frames are sent to the channel which do not correspond to DATA or ACK frames.

Fig. 2 shows a flowchart for the CSMA/CA-DB procedure at the STA and Fig. 3 shows a flowchart for the algorithm at the AP.

4 ns-3 IMPLEMENTATION AND PRELIMINARY RESULTS

In this section, it will be presented some aspects of the implementation, in ns-3, of the proposed CSMA/CA-DB scheme and some preliminary results obtained so far. As so, it will be shown some performance comparisons, obtained with ns-3, between the standard CSMA/CA and the novel CSMA/CA-DB schemes, namely, the aggregated throughput vs the number of STAs in the cell.

REFERENCES

[1] Boris Bellalta. 2016. IEEE 802.11ax: High-Efficiency WLANs In IEEE Wireless Communications Magazine, vol. 23, pp. 38-46, 2016, ISSN 1536-1284. DOI: 10.1109/MWC.2016.7422404
[2] Luis Sanabria-Russo, A. Faridi, B. Bellalta, J. Barcelo, and M. Oliver. 2013. Future Evolution of CSMA Protocols for the IEEE 802.11 Standard. ISSN 2164-7038. DOI: 10.1109/ICCW.2013.6649433.
[3] Luis Sanabria-Russo, B. Bellalta, N. Facchi, and F. Gringoli. 2016. Collision-free Operation in High Density WLAN Deployments. In ArXiv e-prints. 1607.08138..
[4] Rung-Shiang Cheng, and Chung-Ming Huang. 2015. Collision detect and avoidance media access mechanism for next generation 802.11ax networks. In 2015 11th International Conference on Heterogeneous Networking for Quality, Reliability, Security and Robustness (QSHINE), Taipei, 2015, pp. 189-194.
[5] Der-Jiunn Deng, Kwang-Cheng Chen, and Rung-Shiang Cheng. 2014. IEEE 802.11ax: Next Generation Wireless Local Area Networks. In 2014 10th International Conference on Heterogeneous Networking for Quality, Reliability, Security and Robustness (QSHINE), 2014, pp. 77-82.

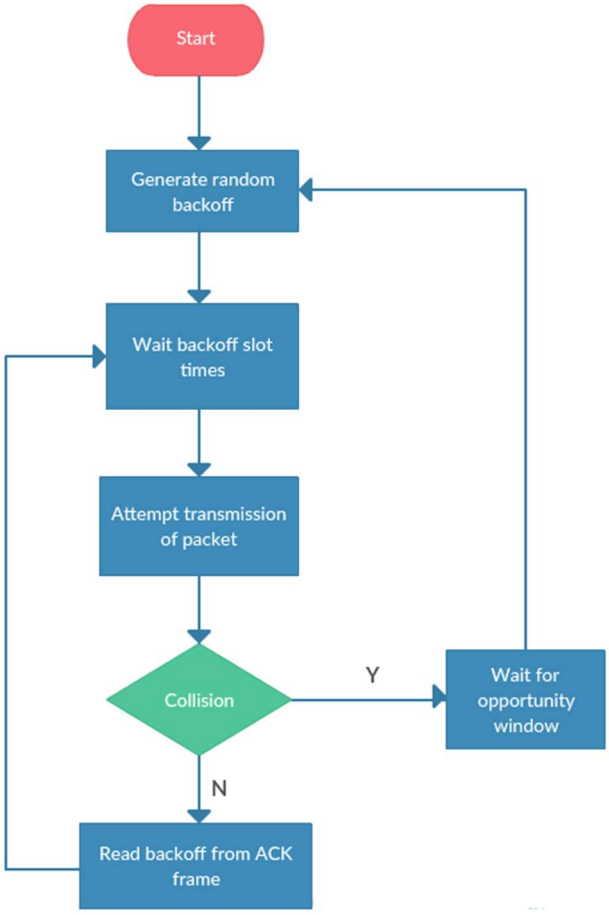

Figure 2: CSMA/CA-DB flowchart for STA.

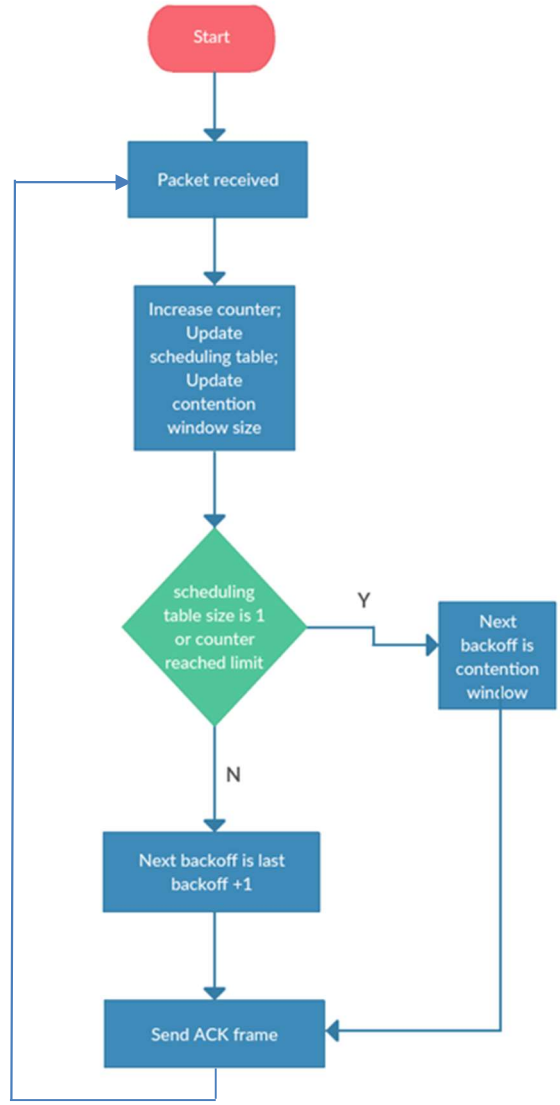

Figure 3: CSMA/CA-DB flowchart for AP.