Achieving Fairness in Carrier Sense Multiple Access with Enhanced Collision Avoidance

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***Abstract*—It is possible to achieve a collision-free state implementing Carrier Sense Multiple Access with Enhanced Collision Avoidance (CSMA/ECA). It differs from CSMA/CA only in choosing a deterministic (instead of random) backoff after successful transmissions. On this work are exposed the fairness issues regarding CSMA/ECA and how they are leveraged by adjusting the number of packets transmitted on each opportunity. Results show a tottaly distributed, collision-free and fair protocol capable of achieving higher levels of throughput than those of the conventional CSMA/CA.**

***Index Terms*—Wireless, MAC, Collision-free, CSMA/ECA.**

I. Introduction

IEEE 802.11 networks use a shared and limited medium to establish communication among nodes. Carrier Sense Multiple Access with Collision Avoidance (CSMA/CA) is the protocol in charge of coordinating access to the wireless medium in order to avoid simultaneous transmissions by different nodes. If two or more nodes (or *contenders* for the medium η) attempt transmission at the same time, a *collision* accurs and the resulting transmission is disregarded by receivers.

Time under CSMA/CA is slotted, that means that it is discrete and furthermore, it is divided in three slot types: *empty*, *successful* and *collision*; accounting for no transmission, successful transmission or collision respectively.

Each contender attempting to transmit a packet chooses a uniformly random *backoff* counter $bo_r \in [0, \ldots, CW_{min} - 1]$, where CW_{min} is referred to as the minimum *contention window* with a typical value of 32. Each passing empty slot decrements bo_r by one; when the backoff counter reaches zero the contender will attempt transmission. The success of the transmission attempt is only confirmed by the reception of an *acknowledgement* (*ack*) from the receiver, otherwise a collision is assumed. If that were the case, each contender involved in the collision doubles its contention window $CW = 2^m CW_{min}, m \in [0, \ldots, 5]$ incrementing the *backoff stage* (m) by one and choosing another uniformly random backoff counter, bo_r. If the transmission was successful, the sender resets its contention window to the minimum value ($CW = CW_{min}$) and chooses another bo_r.

Carrier Sense Multiple Access with Enhanced Collision Avoidance (CSMA/ECA) achieves less collisions and outperforms CSMA/CA in most typical scenarios [1]. The only difference with CSMA/CA is that a deterministic backoff $bo_d = C$ is chosen after each successful transmission. C is defined in Eq. 1 as the *system capacity* and represents the maximum number of host (η) participating in the contend for transmission able to achieve a collision-free state. In Eq. 1, $\lceil\cdot\rceil$ is the ceiling operator, $E[\cdot]$ is the expectation operator, $\mathcal{U}$ is the uniform distribution and CW is the contention window.

$$C = \lceil E[\mathcal{U}[0, CW - 1]]\rceil \quad (1)$$

In a scenario where $\eta \leq C$, eventually all contenders will be able to pick a different transmission slot, therefore achieving a collision-free state.

When the system is overcrowded, $\eta > C$, CSMA/ECA suffers a decrease in throughput as appreciated in Figure 1. This effect is caused by collisions originated by $\eta - C$ contenders forced to generate a random backoff counter and attempting transmission on slots previously picked by C nodes using a deterministic backoff.

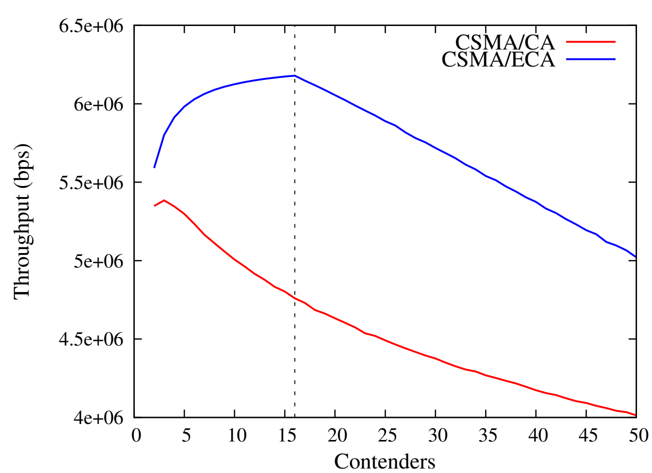

Fig. 1. Throughput and how it is affected when $\eta > C$

In Figure 1, when $\eta > C$ the CSMA/ECA system is overcrowded with contenders and the collision-free state is compromised. As more contenders are introduced, the system behavior tends to be more like CSMA/CA: nodes are forced to choose a random backoff.

In this work, a fully-distributed version of CSMA/ECA is presented and the throughput issue when $\eta > C$ is assessed.

II. A DESCENTRALIZED AND FAIR CSMA/ECA

There are numerous reasons why CSMA/ECA is more useful when modeled as a decentralized protocol. One being the removal of the Access Point (AP) as a single point of failure. Also, AP Beacons are no longer used as a control measure to estimate the number of contenders in the network, which in turn reduces the overall convergence time.

In an overcrowded CSMA/ECA ($\eta > C$), colliding nodes will double CW each time and reset it ($CW = CW_{min}$) upon each transmission success, augmenting its collision probability. This behavior accounts for the throughput reduction in Figure 1.

In order to leverage this issue, CSMA/ECA forces nodes to *stick* to its backoff stage, m. That is, CW is no longer reset after a successful transmission; resulting in a greater system capacity because of the larger CW. This leads to a collision-free state while $\eta \leq C_m$, where C_m accounts for C in Eq. 1 computed with the larger CW.

III. CONCLUSIONS

Test

REFERENCES

[1] J. Barcelo, A. Toledo, C. Cano, and M. Oliver, "Fairness and Convergence of CSMA with Enhanced Collision Avoidance (ECA)," in *2010 IEEE International Conference on Communications (ICC)*, may 2010, pp. 1 –6.