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. Furthermore, the enhanced CSMA/E2CA has stickiness degrees, which refer to number deterministic backoffs used after each successful transmission and account for shorter convergence time towards a collision-free state. Implementing CSMA/E2CA in a totally distributed way revealed the unfair nature of the protocol. This abstract introduces the concept of Fair Share as a way to leverage this issue, which consist of adapting the number of packets to be transmitted accordingly with the backoff stage of each node. Results show a totally 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/E2CA.**

I. Introduction

Carrier Sense Multiple Access with Enhanced Collision Avoidance (CSMA/ECA) achieves less collisions and outperforms CSMA/CA in most typical scenarios. This is done by choosing a deterministic backoff after each successful transmission. Its evolution, CSMA/E2CA introduces stickiness in the process in order to shorten the convergence time towards a collision-free state by setting a number of occasions a deterministic backoff is used after each successful transmission [1] .

Stickiness can reduce the convergence time by orders of magnitude when the number of contenders η is less or equal than the system capacity C as defined in Eq. 1, where $\lceil\cdot\rceil$ is the ceiling operator, $E[\cdot]$ is the expectation operator, $\mathcal{U}$ is the uniform distribution and CW_{min} is the minimum contention window of the system (usually $CW_{min} = 32$ for 802.11 networks).

$$C = \lceil E[\mathcal{U}[0, CW_{min} - 1]] \rceil \tag{1}$$

The system capacity C in turn refers to the time slots available for transmission in the schedule.

In Figure 1, when $\eta > C$ the CSMA/E2CA 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.

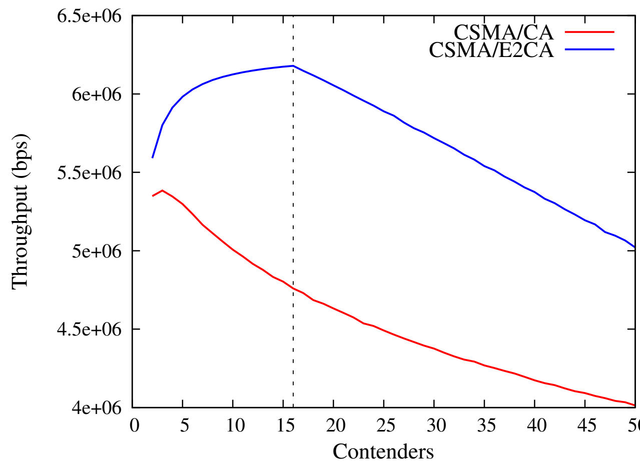

Fig. 1. Throughput and how it is affected when $\eta > C$

In this work, a fully-distributed version of CSMA/E2CA is presented and the throughput issue when $\eta > C$ is assessed using Fair Share.

II. A decentralized and fair CSMA/E2CA

There are numerous reasons why CSMA/E2CA 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.

If $\eta > C$ and under saturation (all contenders have something to transmit, all the time), $\eta - C$ contenders are forced to choose a random backoff, given that there are no unpicked slots available for transmission. This in turn provokes collisions on the C remaining nodes that picked a slot using a deterministic backoff [1].

CSMA/E2CA manages this issue forcing the nodes to *stick* to a deterministic backoff. That is, the contenders will choose a deterministic backoff two times after a successful transmission. If two consecutive collisions occur, then the contender will be forced to double its contention window (by incrementing the backoff stage, m in Eq. 2) and to pick a random backoff. This results in a faster convergence to a collision-free state, but at the same time reduces the fairness of the protocol given that some contenders may have to wait more than others to access the channel.

$$W = 2^m CW_{min},\ m \in [0, ..., 5] \tag{2}$$

A. *Ensuring fairness*

Under CSMA/E2CA, nodes may have different contention windows (W in Eq. 2), this means that some arbitrary contenders have to wait more than others in order to access the channel; compromising the fairness of the protocol. To leverage this issue, nodes are set to transmit 2^m packets every time their backoff counter expires. That is, if a contender doubled its contention window, then it will also double the packets that are going to be transmitted on the next opportunity. This fairness mechanism for CSMA/E2CA is called Fair Share from here on.

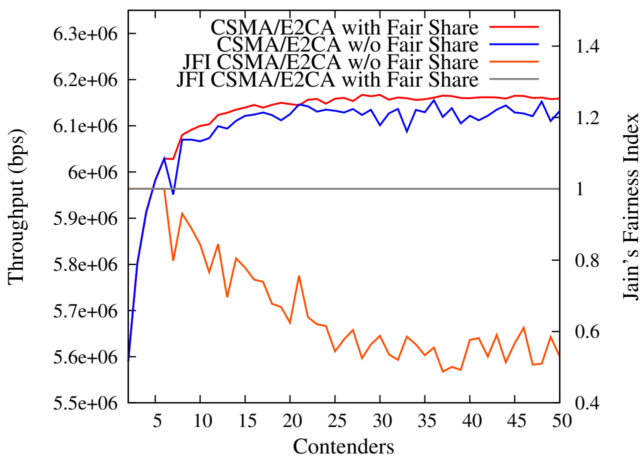

Fig. 2. Throughput and Jain's Fairness Index when implementing Fair Share in CSMA/E2CA

In Figure 2 it is appreciated through the estimation of the Jain's Fairness Index [2] that by implementing Fair Share every contender receives almost the same service time, therefore the system is considered fair.

III. Conclusions

Test

References

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[2] R. Jain, D. Chiu, and W. Hawe, *A Quantitative Measure of Fairness and Discrimination for Resource Allocation in Shared Computer System.* Eastern Research Laboratory, Digital Equipment Corporation, 1984.