

WLANs throughput improvement with CSMA/ECA

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Abstract—Carrier Sense Multiple Access with Enhanced Collision Avoidance (CSMA/ECA) is a totally distributed, collision-free MAC protocol for WLANs capable of achieving greater throughput than the current contention mechanism in WLANs. It does so by changing to a deterministic backoff after successful transmissions, building a collision-free schedule for successful transmitters. This demo shows how CSMA/ECA outperforms the current MAC for WLANs in terms of throughput. This first CSMA/ECA implementation has been done using commercial hardware and OpenFWWF. Besides a throughput gain, results evidence a better collision avoidance by showing a periodic alternation of transmitters following the deterministic backoff.

Index Terms—CSMA/ECA, WLAN, MAC, Collision-free, OpenFWWF.

I. INTRODUCTION

In this demo we show the operation of a WLAN using Carrier Sense Multiple Access with Enhanced Collision Avoidance (CSMA/ECA) [1] and how it outperforms the same network setup using the current MAC for WLANs. Specifically, we observe how four stations transmit messages to a wired station through a commercial Access Point (AP) (see Figure 1). The transmissions and number of received packets are recorded in order to derive the achieved throughput.

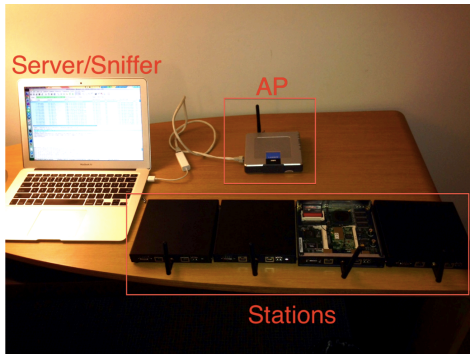


Fig. 1. Demo setup: four Alix 2d2, Iperf server and an AP.

During each test, it is possible to see how CSMA/ECA contention mechanism builds a collision-free schedule for successful transmitters. This is achieved by taking a look at each station's successful transmissions in a sniffer station running Wireshark [2]. All sniffed traffic is then processed at the end of each test to provide interesting metrics like: throughput, retransmissions, successful transmissions and average frame inter-arrival times for each station.

II. CARRIER SENSE MULTIPLE ACCESS WITH ENHANCED COLLISION AVOIDANCE

Carrier Sense Multiple Access with Enhanced Collision Avoidance (CSMA/ECA) is a totally distributed and collision-free MAC protocol for WLANs. Stations build a collision-free schedule picking a deterministic backoff, B_d , after successful transmissions. Collisions are handled as in Carrier Sense Multiple Access with Collision Avoidance (CSMA/CA):

- If the transmitter does not receive an acknowledgement (ACK) from the receiver of a specific transmission, a collision is assumed.
- The colliding nodes increment their backoff stage, k , in one ($k \in [0, m]$, where m is the maximum backoff stage of typical value $m = 5$) and pick a random backoff, $B \sim U[0, 2^k CW_{\min}]$, where CW_{\min} is the minimum contention window with typical value $CW_{\min} = 16$.

In Figure 2, four stations (STA) are involved in a contention to access the channel using CSMA/ECA. The horizontal lines represent time and are composed of empty slots and transmissions. Each empty slot decrements the backoff by one, so the numbers indicate how many empty slots are left until the expiration of the corresponding STA's backoff. At the first slot, the outline points out that STA 3 and STA 4 have picked the same random backoff and will eventually collide. Upon collision, these two stations will recompute a random backoff.

It is not until a station is able to make a successful transmission that it changes to a deterministic backoff. In Figure 2, STA 4 is able to successfully transmit after the random backoff expires, and then it generates a deterministic backoff ($B_d = 7$) for the next transmission. This way CSMA/ECA builds a collision-free schedule for successful transmitters. Further extensions to CSMA/ECA enable it to construct a collision-free schedule for many more contenders [3].

III. DEMO

By making simple changes to the OpenFWWF [4] open firmware for WLAN network cards, the built-in MAC is modified to mimic CSMA/ECA behavior.

A CSMA/ECA station is prototyped using OpenFWWF firmware into Broadcom BCM4318 chipset Wireless Network Interface Controller (WNIC), which is connected to a mini-PCI slot inside a PC Engines Alix 2d2 [5] station. This CSMA/ECA implementation in commercial hardware will be referred to as CSMA/ECA_{test} from this point forward. Further implementation details using commercial PCs can be found in [6].

The testing scenario is composed of four saturated stations running CSMA/ECA_{test}. Each station is placed at equal distance from the Access Point (AP), to which an Iperf [7] server is connected via Ethernet, as in Figure 1. Stations are set to transmit dummy 1470 byte UDP segments at 65 Mbps towards the server, and the transmissions are captured using Wireshark in a separate wireless station so they can be visualised in real time or saved for processing at a later time. The transmission speed is set to 65 Mbps to purposely saturate the stations.

IV. RESULTS

The bar chart displays the maximum throughput per station in Mbps for two protocols: CSMA/CA and CSMA/ECA. The y-axis ranges from 0 to 12 Mbps, with a dashed horizontal line at 9 Mbps representing the maximum throughput for a CSMA/ECA station. The legend identifies four stations: STA-1 (white bar), STA-2 (cross-hatched bar), STA-3 (diagonal-hatched bar), and STA-4 (solid black bar).

Protocol	STA-1 (Mbps)	STA-2 (Mbps)	STA-3 (Mbps)	STA-4 (Mbps)
CSMA/CA	3.1	4.0	4.0	3.2
CSMA/ECA	5.8	6.5	7.0	5.6

Even though a higher throughput is achieved, CSMA/ECA_{test} nodes do not maintain a collision-free schedule all the time. Stations are unable to transmit in the exact slot indicated by the deterministic backoff, resulting in a slight drift in time of their transmissions, increasing the probability of collisions. Figure 4 shows the schedule for CSMA/ECA_{test} (up) and CSMA/CA (down), where a drift can be appreciated at CSMA/ECA_{test}:STA 1's second transmission. Similar effects resulting in collisions are responsible for the deviation from the maximum achievable throughput represented by the dotted line in Figure 3.

The demo shows how CSMA/ECA can converge to a TDMA-like schedule by making small modifications to the WNIC's firmware; having as a result a throughput increase over the current MAC scheme in WLANs.

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