Dynamic Parameter Adjustment in CSMA/ECA

J. Barcelo, B. Bellalta, C. Cano, A. Sfairopoulou, M. Oliver

Universidad Carlos III de Madrid Universitat Pompeu Fabra

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Outline

Motivation

- CSMA/ECA, a novel approach to contention

Contribution

- Performance assessment for different values of CW_{min}
- Centralized tuning of CW_{min}

Conclusion

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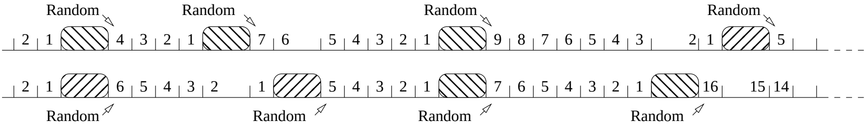
A simple scenario

- Stations are close to each other. They are in each other's transmission range.
- The stations are saturated. A station has always a packet ready to transmit.
- A single-hop ad-hoc network with no hidden terminal is considered.

Carrier Sense Multiple Access with Collision Avoidance (CSMA/CA)

- CSMA/CA is a multiple access protocol.
- Channel time is divided in slots.
- Stations defer their transmissions a random number of slots. The random value is selected from a contention window.
- If two or more stations transmit in the same slot, a collision occurs, and the transmitted packets might be lost.
- Collisions seriously deteriorate the performance of the network.

A graphical representation of CSMA/CA



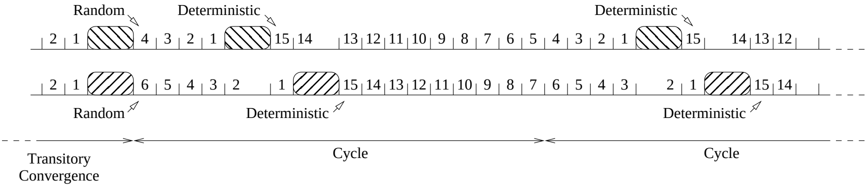
(Busy slots are actually orders of magnitude longer than the empty ones.)

Carrier Sense Multiple Access with Enhanced Collision Avoidance (CSMA/ECA)

BACKOFF	CSMA/CA	CSMA/ECA
initial	random	random
after collision	random	random
after success	random	deterministic

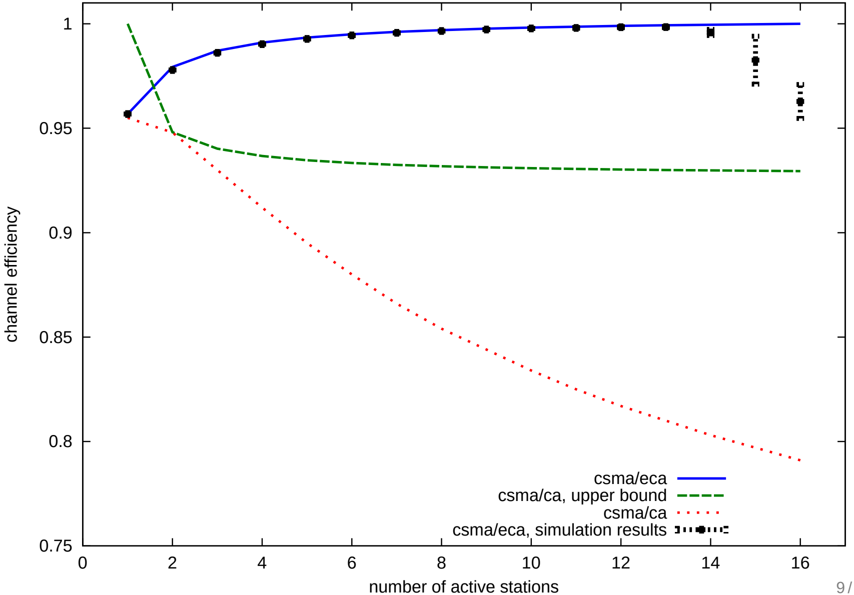
- Two stations that successfully transmitted in their last transmission attempt, will not collide among them in their next transmission attempt. The number of collisions is reduced.
- After a transient state, the system reaches collision-free operation.
- The deterministic backoff value (V) is chosen to be halve of the minimum contention window (CW_{min}). In the following example $CW_{min} = 32$ and $V = 16$.

A graphical representation of CSMA/ECA



(Remember that busy slots are actually substantially longer than the empty ones. That means that, in the absence of collisions, channel efficiency is close to 1.)

Performance Comparison

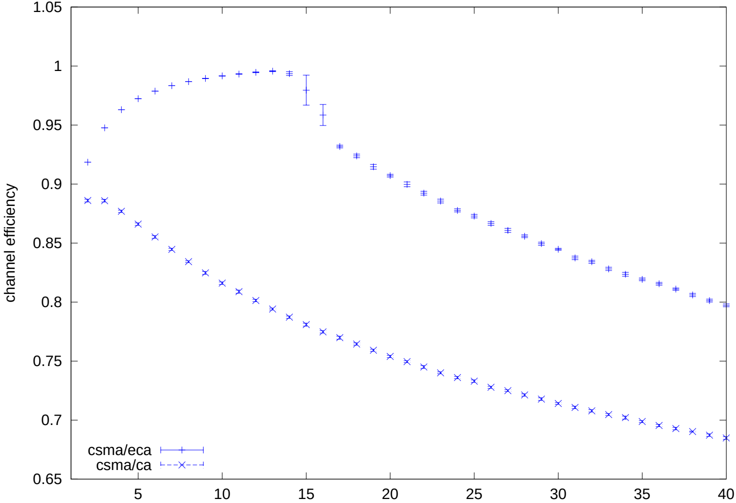


CSMA/ECA outperforms CSMA/CA

- By suppressing collisions, CSMA/ECA increases the fraction of channel time devoted to successful transmissions.
- The blue curve represent the analytical results in steady-state conditions.
- The black dots represent simulation results that include the transient-state.
- The inclusion of the transient state in simulations accounts for the small difference between the two curves.

It is not possible to reach collision-free operation when the number of contenders exceeds the deterministic backoff value

Chanel efficiency when $V = 16$.



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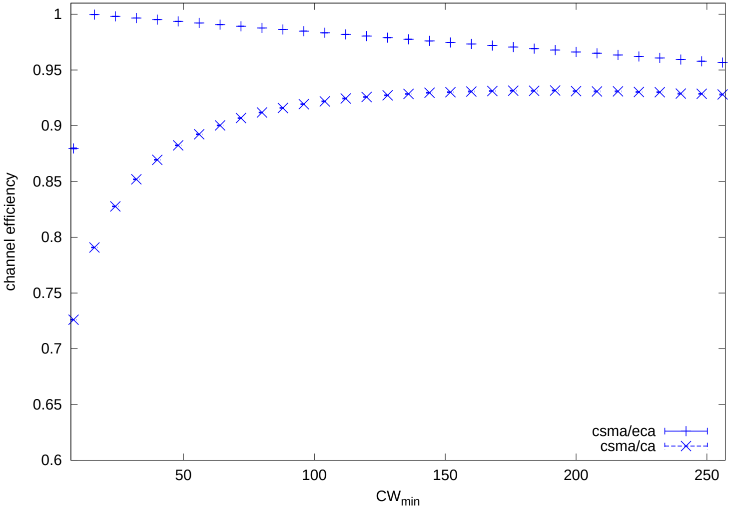
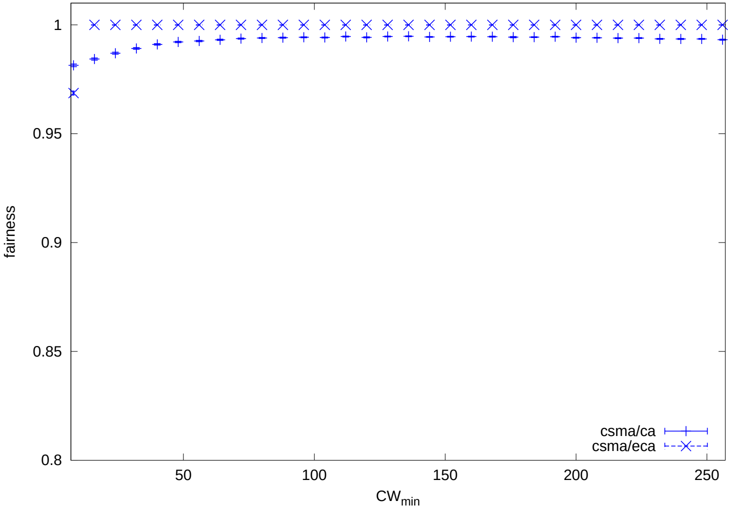
We will use simulation to study channel efficiency and fairness

- Ideal channel
- Fixed number of active contenders (8)
- CW_{min} from 8 to 256
- Long simulations in the steady-state.
- Short simulations (1000 slots) including transient state.

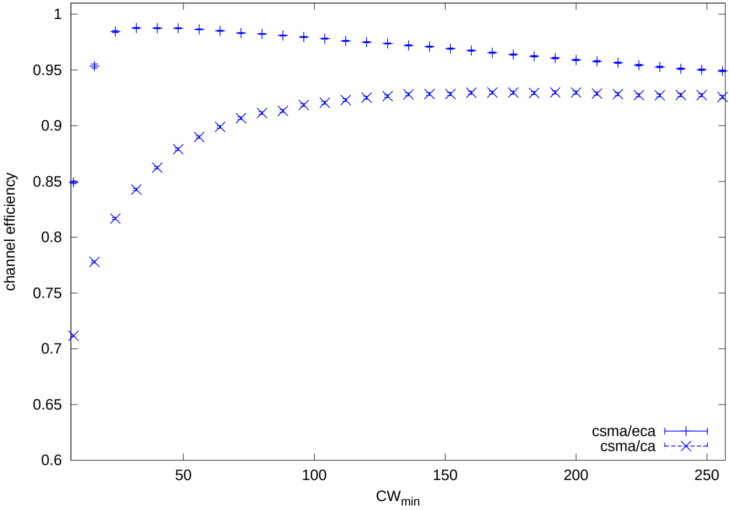
Channel efficiency in the steady state



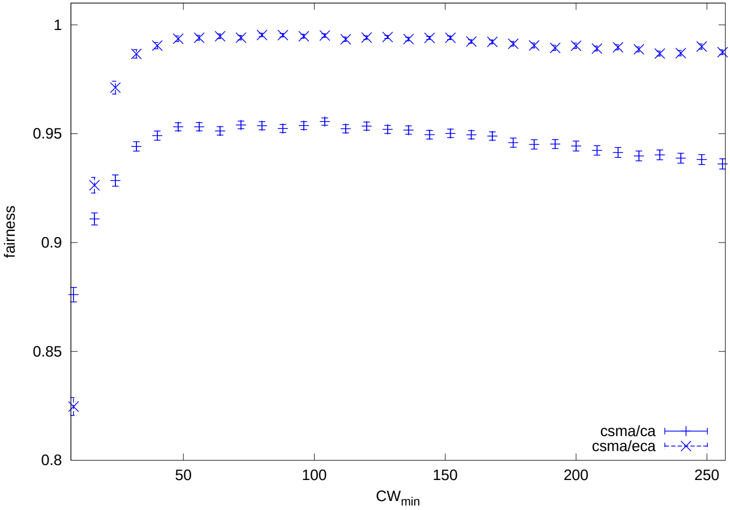
Fairness in the steady state



Channel efficiency in the transient state



Fairness in the transient state



What is the best value for CW_{min}?

This is a difficult question. The answer depends on ...

- The number of simultaneous contenders.
- The network dynamics.
- Frame error rates.
- Packet size distribution.
- Performance metric (fairness or efficiency).

Our goal is to obtain reasonable performance for a variety of scenarios. Ideally, we would like to operate in a collision-free fashion.

We make the (arbitrary) decision to operate with a fraction of $\sim 25\%$ of busy slots. I.e., a CW_{min} eight times larger than the number of contenders.

A centralized approach to adjust CW_{min}

- The access point monitors the number of busy slots in the channel.
- It measures the fraction of busy slots (β) between beacons (approx. 100ms).
- It updates the value of CW_{min} to reach a fraction of busy slots which is close to our target value 25 % (β_{target}).
- It distributes the new value CW_{min} value to the contenders.
- The standard requires that CW_{min} is an integer power of two.

$$\beta_{target} = \frac{1}{4}$$

$$\begin{array}{ll} CW_{min,0} = CW_{min}^{default}, & i = 0 \\ CW_{min,i+1} = \max(CW_{min}^{default}, CW_{min,i} \cdot 2^{round(\log_2(\beta/\beta_{target}))}), & i > 0 \end{array}$$

20 stations simultaneously join the contention

time (s)	CW_{min}	Success	Collision	Empty	Efficiency	Fairness
0-0.1	32	33	27	30	0.55	0.45
0.1-0.2	64	53	5	31	0.91	0.62
0.2-0.3	128	56	2	90	0.95	0.72
0.3-0.4	256	56	1	208	0.94	0.80
0.4-0.5	256	57	0	210	0.96	0.87
0.5-0.6	256	56	0	202	0.96	0.93
0.6-0.7	256	57	0	203	0.96	0.93

time (s)	Efficiency (average)	stdev	Fairness (average)	stdev
0-0.1	0.60	0.05	0.45	0.05
0.1-0.2	0.83	0.05	0.56	0.08
0.2-0.3	0.92	0.03	0.68	0.07
0.3-0.4	0.94	0.02	0.76	0.09
0.4-0.5	0.95	0.02	0.82	0.09
0.5-0.6	0.95	0.02	0.85	0.08
0.6-0.7	0.95	0.01	0.90	0.07

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Summary

- We propose parameter adjustment approach that will be useful to accommodate a variable number of contenders in a CSMA/ECA network.

Thank you for your attention.