Fairness in Collision-Free WLANs

INFOCOM 2013, Turin, Italy

Luis Sanabria-Russo, Jaume Barceló, Boris Bellalta
Universitat Pompeu Fabra, Barcelona, Spain

Universitat Pompeu Fabra Barcelona

NeTS research group
Network Technologies and Strategies

Motivation

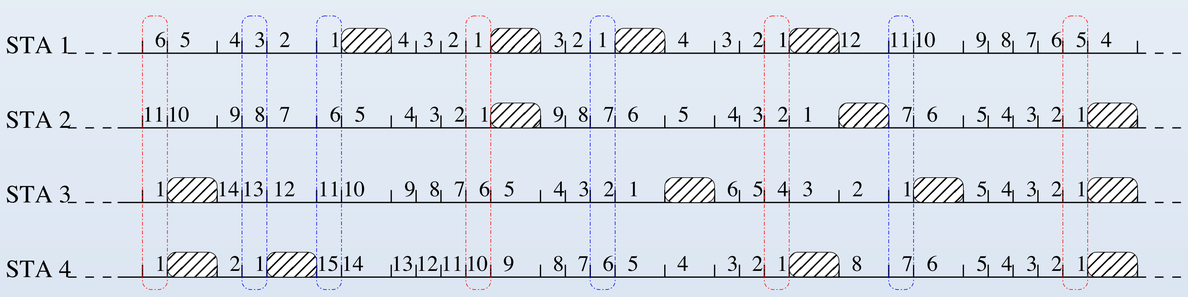
Wireless LANs are composed of nodes that must contend for the medium in a distributed manner. If two or more contenders attempt transmission at the same time, a collision occurs.
Collisions are the main cause of throughput degradation in Wireless Local Area Networks (WLANs), so by constructing collision-free WLANs one can attain greater levels of throughput.

CSMA/CA

Carrier Sense Multiple Access with Collision Avoidance (CSMA/CA) is the most widely used protocol for medium access control (MAC) in WLANs. CSMA/CA's job is to coordinate access to the medium for each contender.

When a node has something to transmit:

- Picks a random backoff counter $B \in [0, CW(k) - 1]$, where $CW(k) = 2^k CW_{\min}$ is the contention window, with $CW_{\min}$ its minimum value.
- Each passing empty slot decrements B by one. Contenders attempt transmission when the counter expires ($B = 0$).
- If there is a collision:
  - Colliding nodes increment the backoff stage (k) in one.
- After a successful transmission, the contender resets is backoff stage ($k = 0$).



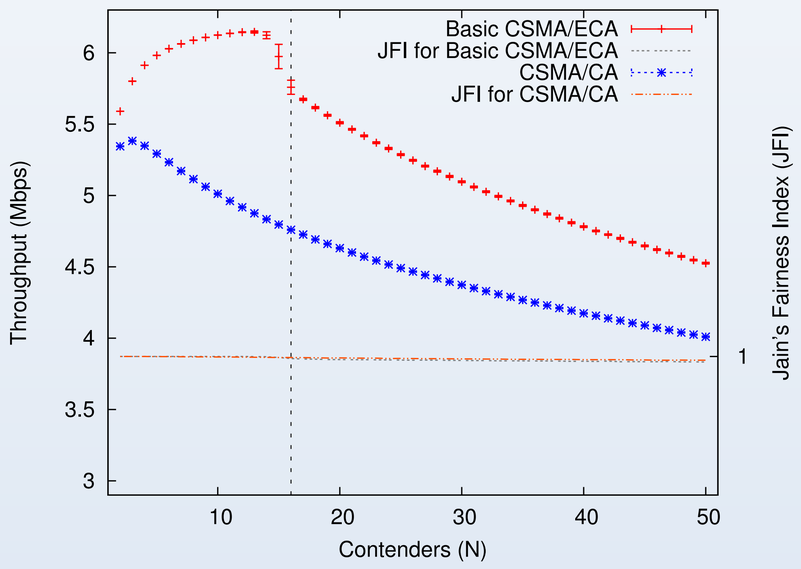
Example CSMA/CA behavior ($CW_{\min} = 16$).

Basic CSMA/ECA

CSMA/CA relies in a random backoff counter (B) which by its nature generates collisions. Furthermore, CSMA/CA instructs nodes to reset the backoff stage (k) after a successful transmission: increasing the collision probability.

Carrier Sense Multiple Access with Enhanced Collision Avoidance [1] (Basic CSMA/ECA):

- Picks a deterministic backoff counter $B_d = CW_{\min}/2$ after successful transmissions.
- Achieves a collision-free state.
- Basic CSMA/ECA's throughput goes beyond CSMA/CA's.



Throughput and fairness in CSMA/CA and Basic CSMA/ECA ($CW_{\min} = 32$).

Nevertheless, when the number of contenders surpasses $CW_{\min}/2$, the system incurs in a mixed behavior; some nodes pick a random and others a deterministic backoff counter. This setup has undesired repercussions in the attained throughput, approximating Basic CSMA/ECA's to CSMA/CA's.

CSMA/ECA + hysteresis and fair share

CSMA/ECA is totally distributed, that means that the number of nodes is unknown to all contenders. So, to make it possible to achieve a collision-free state with more than $CW\min/2$ contenders, CSMA/ECA:

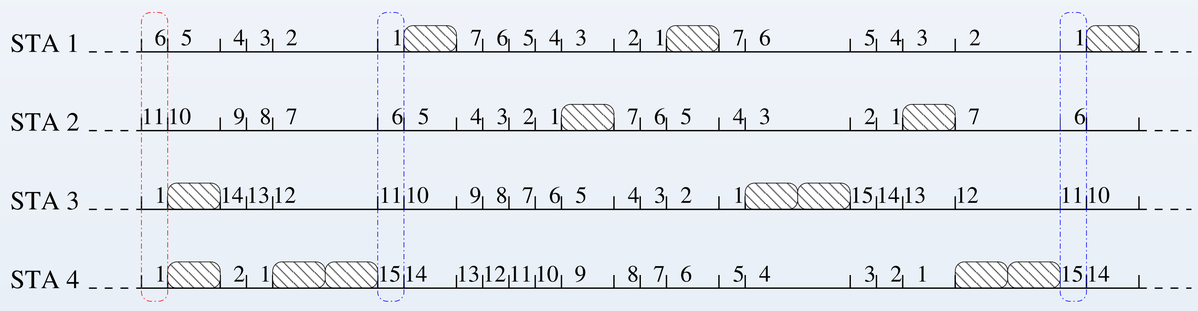
- Instructs nodes **not** to reset their backoff stage after successful transmissions.
- Picks a new deterministic backoff $B_d = CW(k)/2$.

We called this measure *hysteresis*.

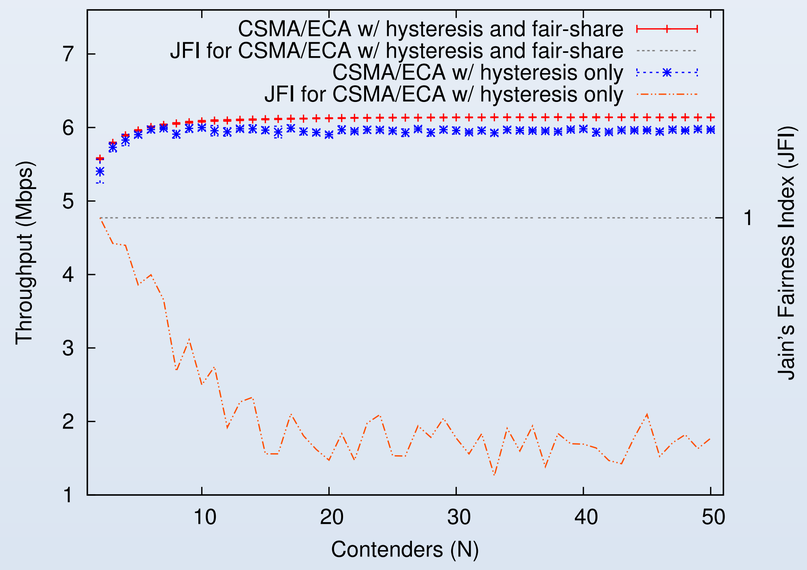
With hysteresis some nodes may have larger B_d than others. This unfairness issue is averted by:

- Allowing nodes at backoff stage k to send 2^k packets.

This is called *fair share* [2].



Example CSMA/ECA behavior with hysteresis and fair share ($CW_{\min} = 16$).



Throughput and fairness when incorporating hysteresis and fair share to CSMA/ECA.

Conclusions and Future plans

Hysteresis allows CSMA/ECA to allocate any number of contenders in a collision-free state, while fair share compensates the unfairness issue; allowing CSMA/ECA to attain greater throughput than CSMA/CA under most typical conditions.
As future work, we plan to:

- Test CSMA/ECA under non-saturated scenarios.
- Implement IEEE 802.11e EDCA quality of service measures.
- Implement CSMA/ECA in cheap commodity hardware [3].

References

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

[2] Sanabria-Russo, L. and Barcelo, J. and Bellalta, B. Fairness in Collision-Free WLANs. *ArXiv e-prints* , February 2013.

[3] Tinnirello, I. and Bianchi, G. and Gallo, P. and Garlisi, D. and Giuliano, F. and Gringoli, F. Wireless MAC processors: Programming MAC protocols on commodity Hardware. *INFOCOM, 2012 Proceedings IEEE* , march 2012, pp 1269–1277.