Fairness and convergence of CSMA with Enhanced Collision Avoidance (ECA)

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Outline

Motivation

- CSMA/ECA, a novel approach to contention

Contribution

- Modelling the transient state
- Coexistence with legacy stations

Conclusion

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Conclusion

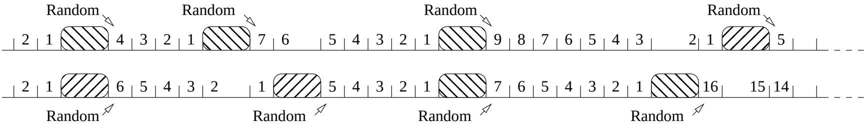
A simple scenario

- 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.

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 $V = 16$.

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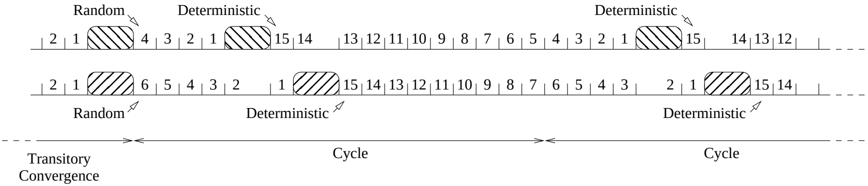
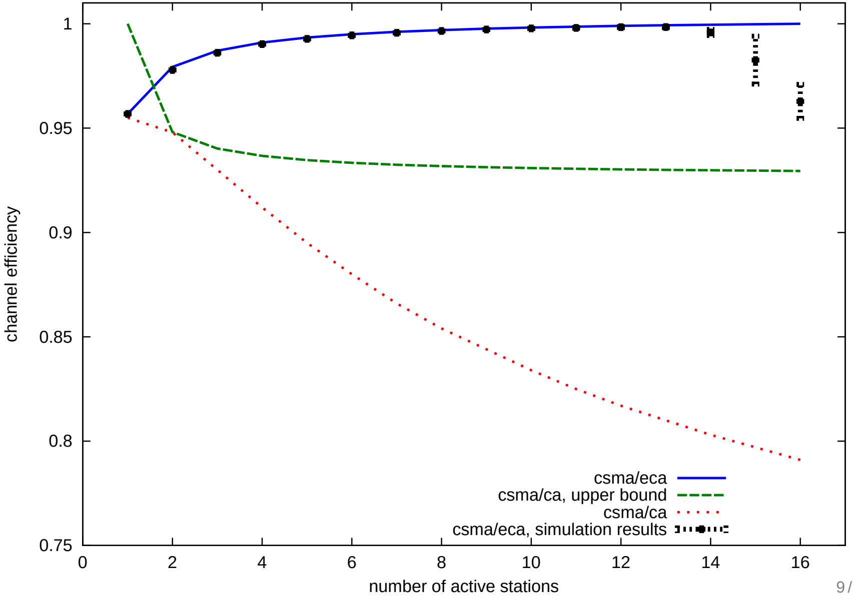


(Remember that busy slots are actually substantially longer than the empty ones. That means that, in the absence of collisions, channel efficiency is close to 1.)

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.

And the questions are ...

- What are the chances of reaching the collision-free steady-state by slot n?
- What happens if we deploy our proposed protocol in a network with stations running the legacy protocol?

Outline

A Markov Chain

- Current state is the number of stations that successfully transmitted in their last transmission attempt, eg.,
  - 4 stations in total
  - none successfully transmitted in its last attempt
  - all use random backoff
  - then we say that the current state is S_0
- We compute the probabilities that each of those stations succeeds or fails in the next transmission attempt.
- And we obtain the transition probabilities of the MC.

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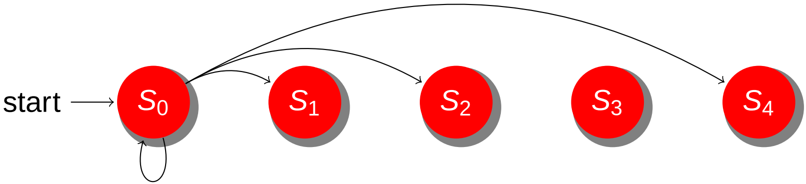

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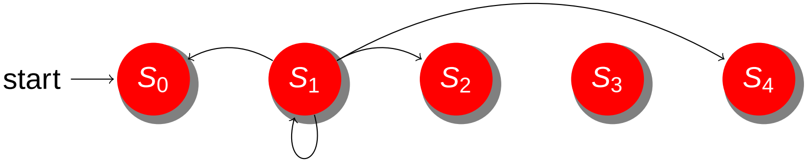

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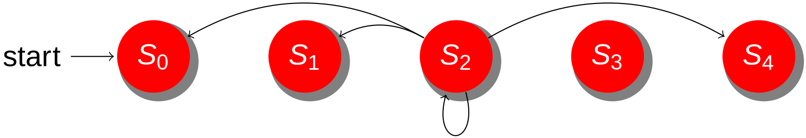

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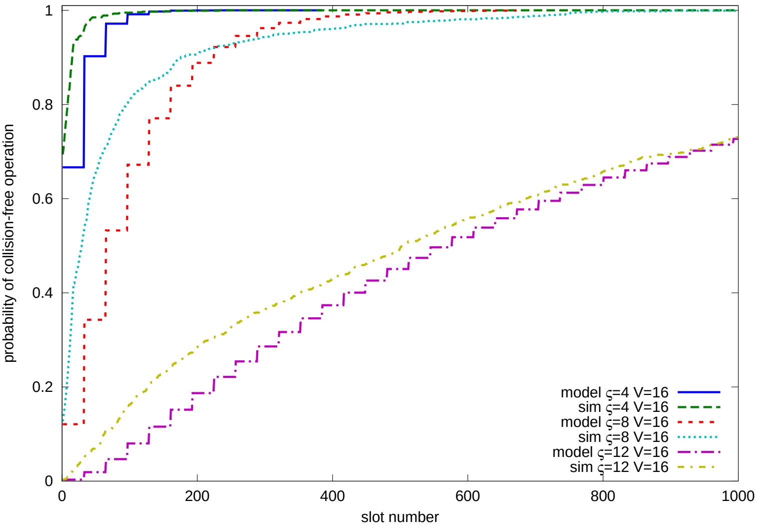
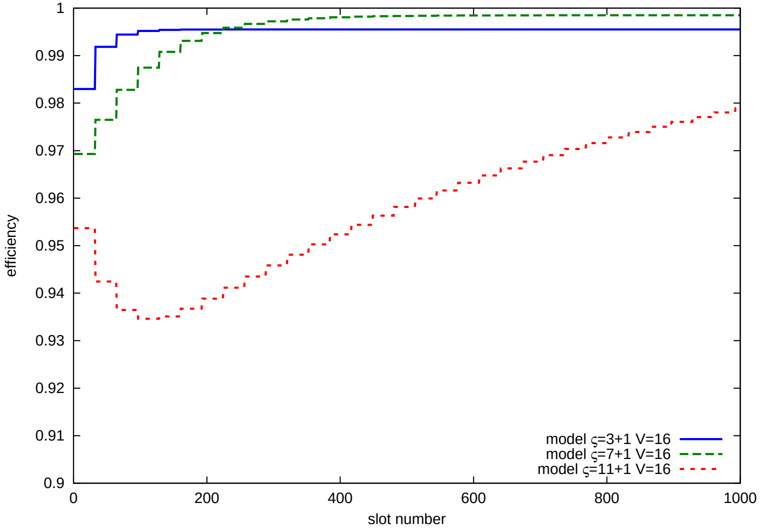
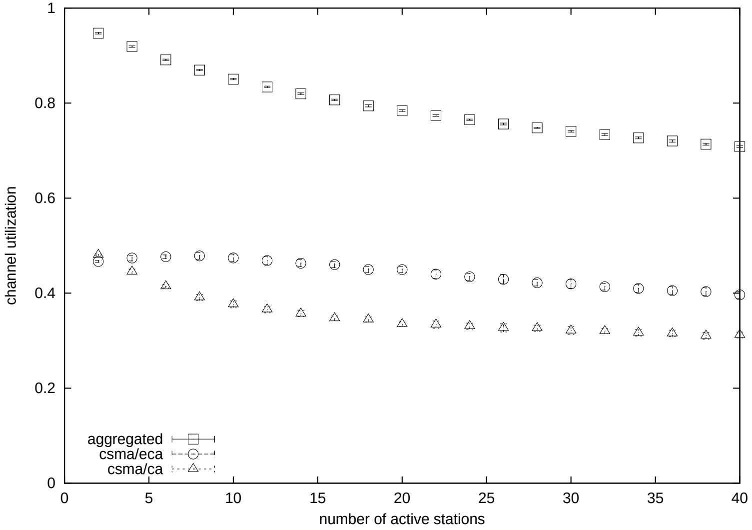
Probability of reaching the absorbing state by slot *n*



Performance "glitch" after a packet loss or new station



CSMA/ECA stations fairly coexist with legacy ones



Outline

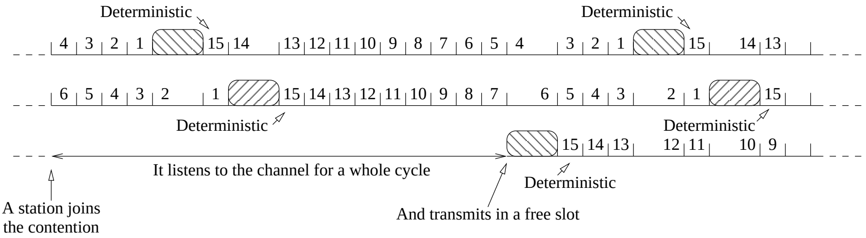
Summary

- CSMA/ECA goes through a transient-state before reaching the collision-free steady-state.
- The transient state can be modelled as a Markov Chain.
- CSMA/ECA stations fairly coexist with legacy ones.

Thank you for your attention.

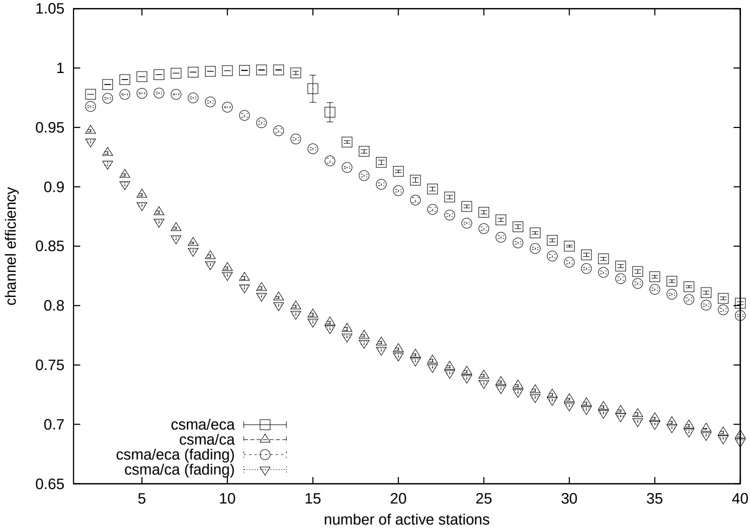
FAQ #1: Can you avoid the performance glitch associated with the entry of a new contender?

Yes, we can. We call it smart entry.



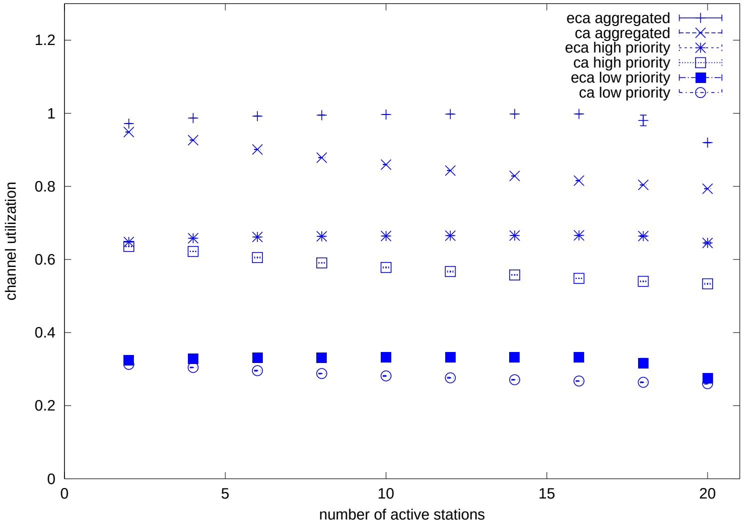
FAQ #2: What if the channel introduces errors?

The performance of CSMA/ECA degrades gracefully. This is a plot with a packet loss rate of 10^{-2}.



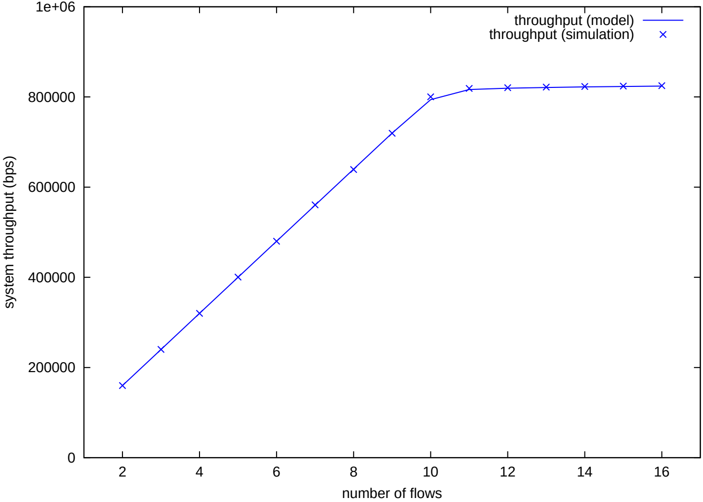
FAQ #3: What if need prioritization?

CSMA/ECA supports the prioritization techniques of IEEE 802.11e (with the exception of AIFS).



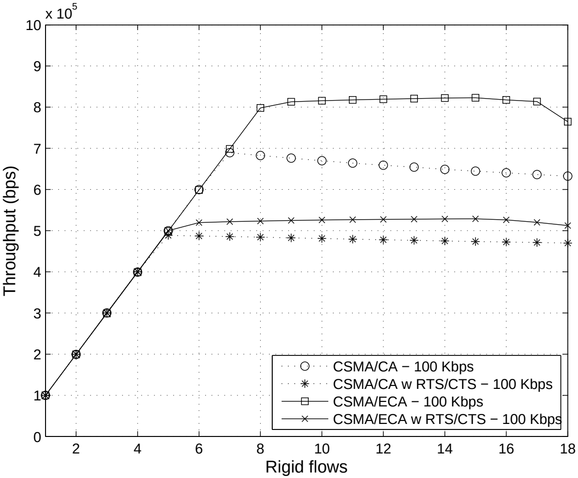
FAQ #4: Can you model the performance of CSMA/ECA in the steady state?

Yes, we can. The following is a plot for a 2 Mbps data rate and an increasing number of 80 kbps flows.



FAQ #5: What if the stations are not saturated?

When the stations are not saturated, the network can absorb all the traffic that it is offered. As soon as the load increases, the advantages of CSMA/ECA become evident. It supports a higher number of 'rigid' (udp-like) flows.



FAQ #6: What if the number of contenders is extremely large?

When the number of contenders is extremely large, it may be desirable to adjust the contention parameters using the tools provided in IEEE 802.11e. A paper that proposes a simple approach to dynamically adapt the contention parameters of CSMA/ECA is undergoing peer revision and it will appear soon. An example of the behaviour of our proposed algorithm when the number of contenders instantaneously jumps from 0 to 20:

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