Idle Sense:
An Optimal Access Method for High Throughput and Fairness in Rate Diverse Wireless LANs

Martin Heusse, Franck Rousseau,
Romaric Guillier, Andrzej Duda

LSR-IMAG Laboratory
Grenoble

Logiciels
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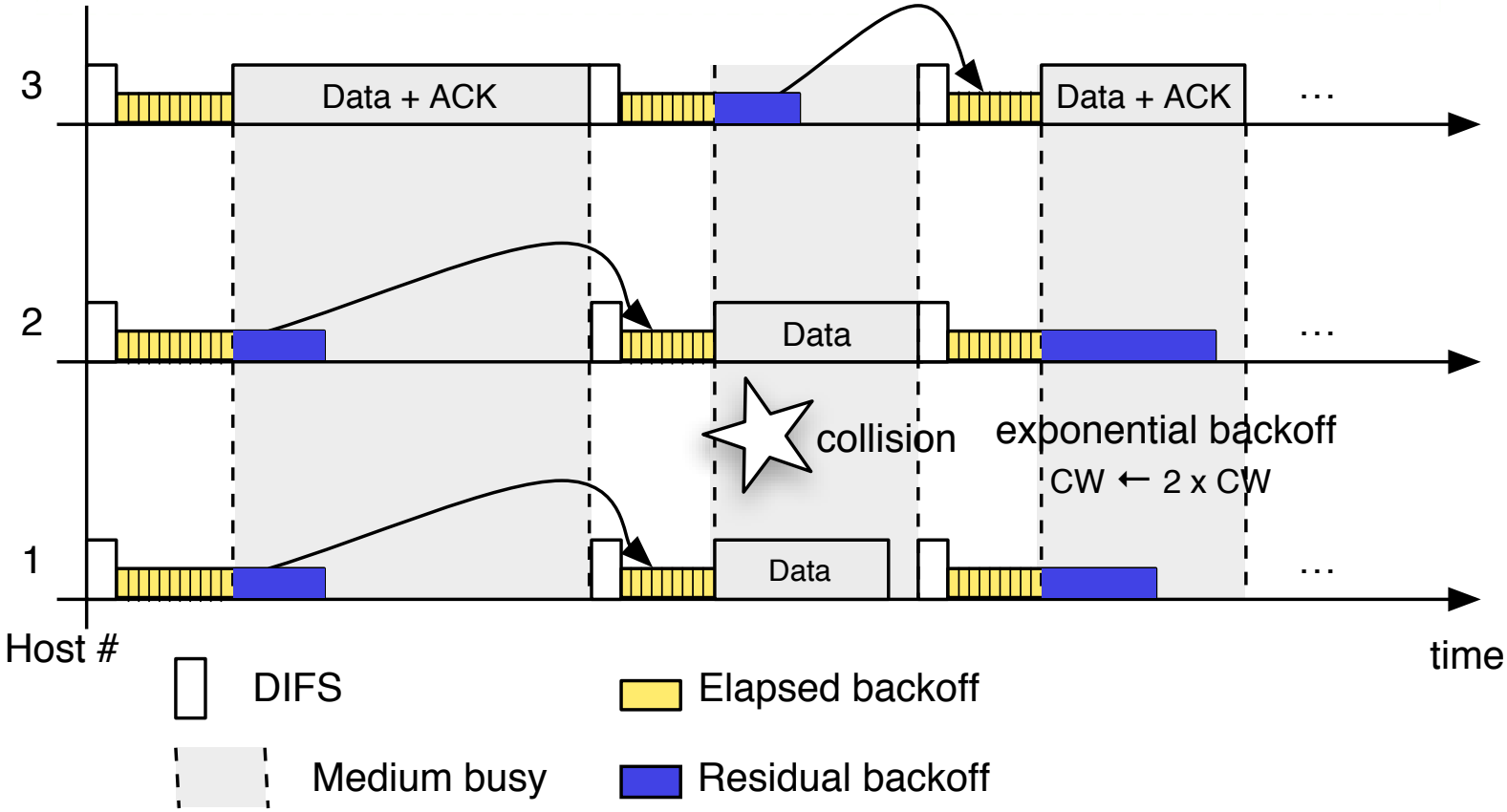
Outline

- 802.11 DCF principles and shortcomings
- Towards a better access method
- *Idle Sense* principles and properties
- Performance evaluation

802.11 DCF in a nutshell



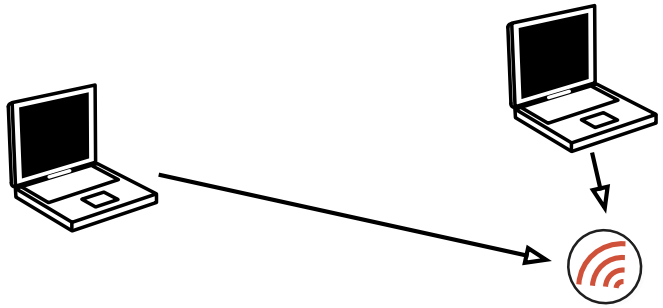
Known shortcomings of DCF

- Under optimal throughput for N > 4
  - Hosts are too aggressive ⇒ collisions
  - CW too small, not enough time spent in contention
- Exponential backoff
  - Good short term fairness for N=2, degrades for larger N
- Performance anomaly in rate diverse cells
  - Slow host limits the throughput of faster hosts

Known shortcomings of DCF

- Contention control in DCF
  - "Bad day" effect
    - If a host looses frames due to bad transmission conditions, it performs frequent exponential backoffs
    - Increased CW lowers the transmission attempt probability
  - Physical capture effect

Physical layer capture effect



- The stronger signal in a collision may be successfully received
- It causes long term unfairness
  - Farther host has a greater average contention window

(Kochut *et al.*, ICNP'04)

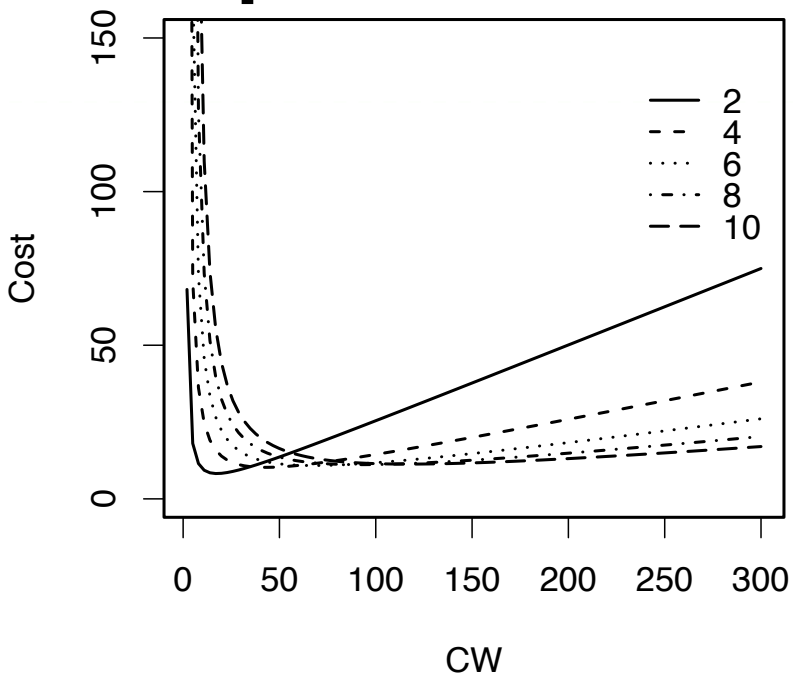
Towards a better access method

- Keep good aspects of DCF
  - No explicit information exchange
  - Keep backoff procedure: random backoff
- Modifications
  - No exponential backoff
    - make hosts use similar values of CW ⇒ fairness
  - Adapt CW to varying traffic conditions
    - more hosts, bigger CW; less hosts smaller CW
    - do not change CW upon frame loss

Idle Sense

- Observe the number of idle slots
  - Channel load indicator
- Control CW
  - Adjust CW to the current state
  - Optimal operation in all conditions
    - What is the optimal CW?
    - How it relates to the number of idle slots?

Optimal CW

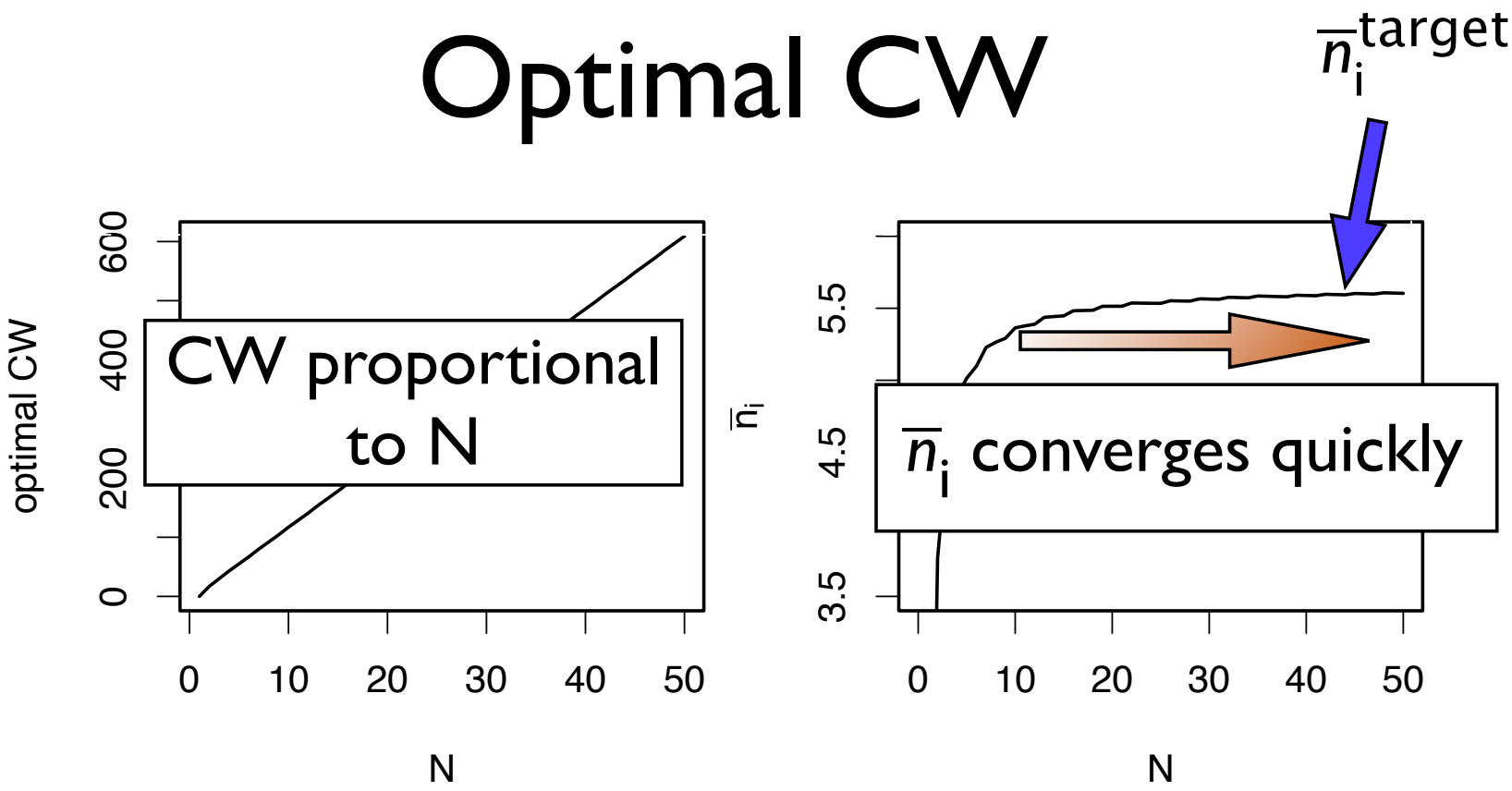


Cost function: Proportion of time spent in collisions or contention

Minimizing the cost ⇒ Maximizing throughput

(Calì *et al.*, Transactions on Networking, 2000)

Optimal CW



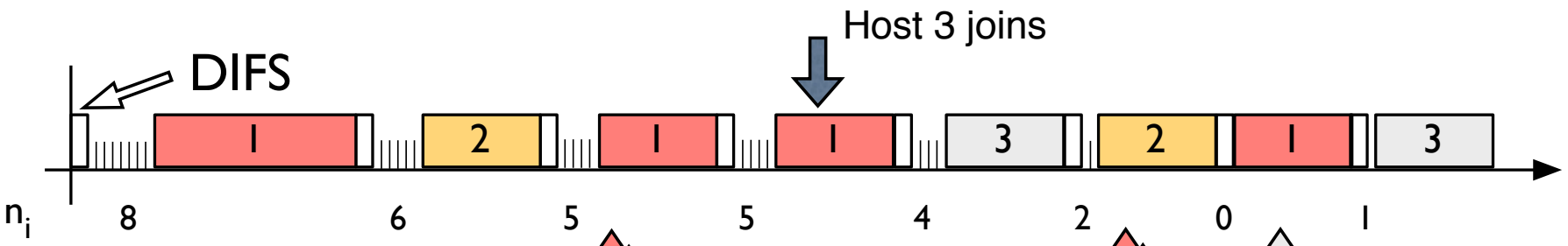
$\overline{n}_i$: average number of idle slots between transmission attempts

Idle Sense

- Hosts track $\overline{n}_i$ and make it converge to the target value
  - Each host estimates $\overline{n}_i$
  - Rises/Lowers CW when $\overline{n}_i$ too small/big compared to $\overline{n}_i^{target}$
  - Adjusting CW is done according to AIMD

  $\Rightarrow$ all hosts converge to a similar value of CW

Example



CW_1=28

CW_2=25

CW_3=25

$\hat{n}_i$ = 6.3
CW_1=25

$\hat{n}_i$ = 6.3
CW_2=22

$\hat{n}_i$ = 3.7
CW_1=30

$\hat{n}_i$ = 3.7
CW_2=26

$\hat{n}_i$ = 2
CW_3=30

2 active hosts

(α= 1/1.2, ϵ=0.01, ntrans=3, $\overline{n}_i^{target}$ = 5.7)

Properties

- Contention control independent of frame loss detection
  - No "bad day" effect
  - Solves the physical layer capture effect
- Short term fair
- Fixes performance anomaly
  - Time fairness achieved by scaling CW according to the transmission rate
- Hidden terminal problem: use RTS/CTS
- No hardware modification required

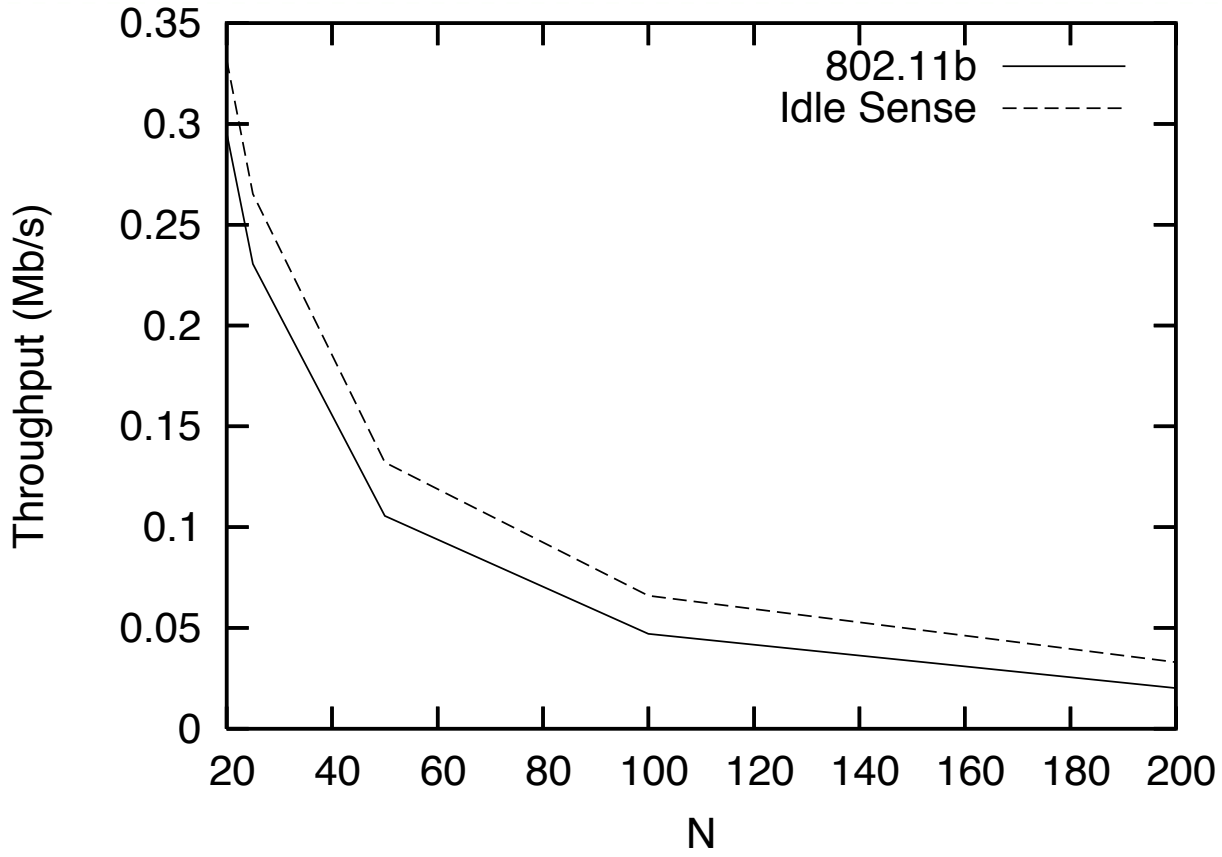
Properties: Channel adaptation

- With *Idle Sense*, the collision probability P_c is known and bounded (after convergence)
  - Frame loss probability $P_{err} \approx 1 - P_c - P_{ok}$
    - P_{ok} can be observed
- Provides a new means for setting the right transmission rate
  - Change rate when P_{err} exceeds a given threshold
  - May be combined with SNR measurements

Performance evaluation

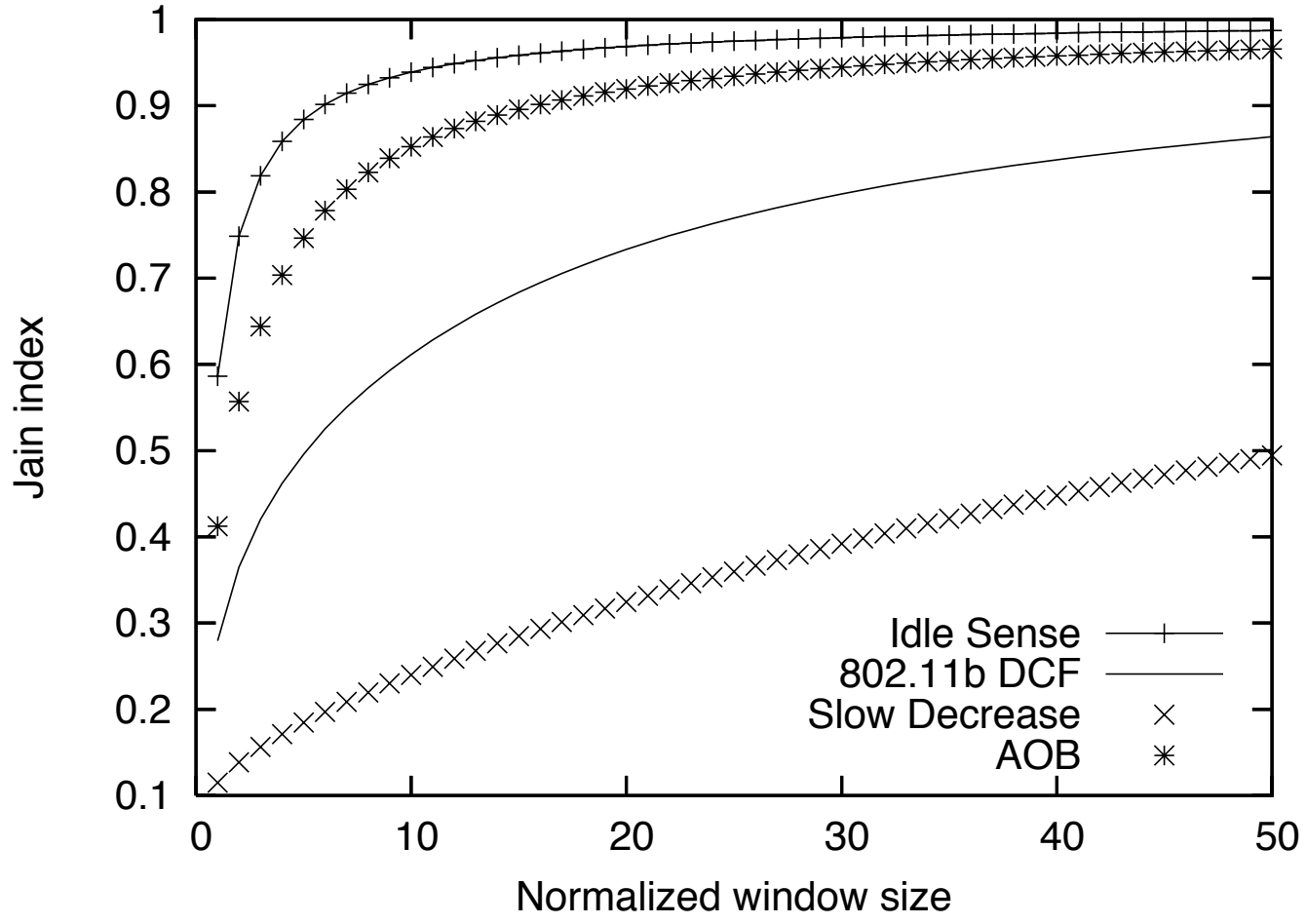
- Throughput
- Fairness: Jain index
- Convergence speed
- Time fairness

Throughput

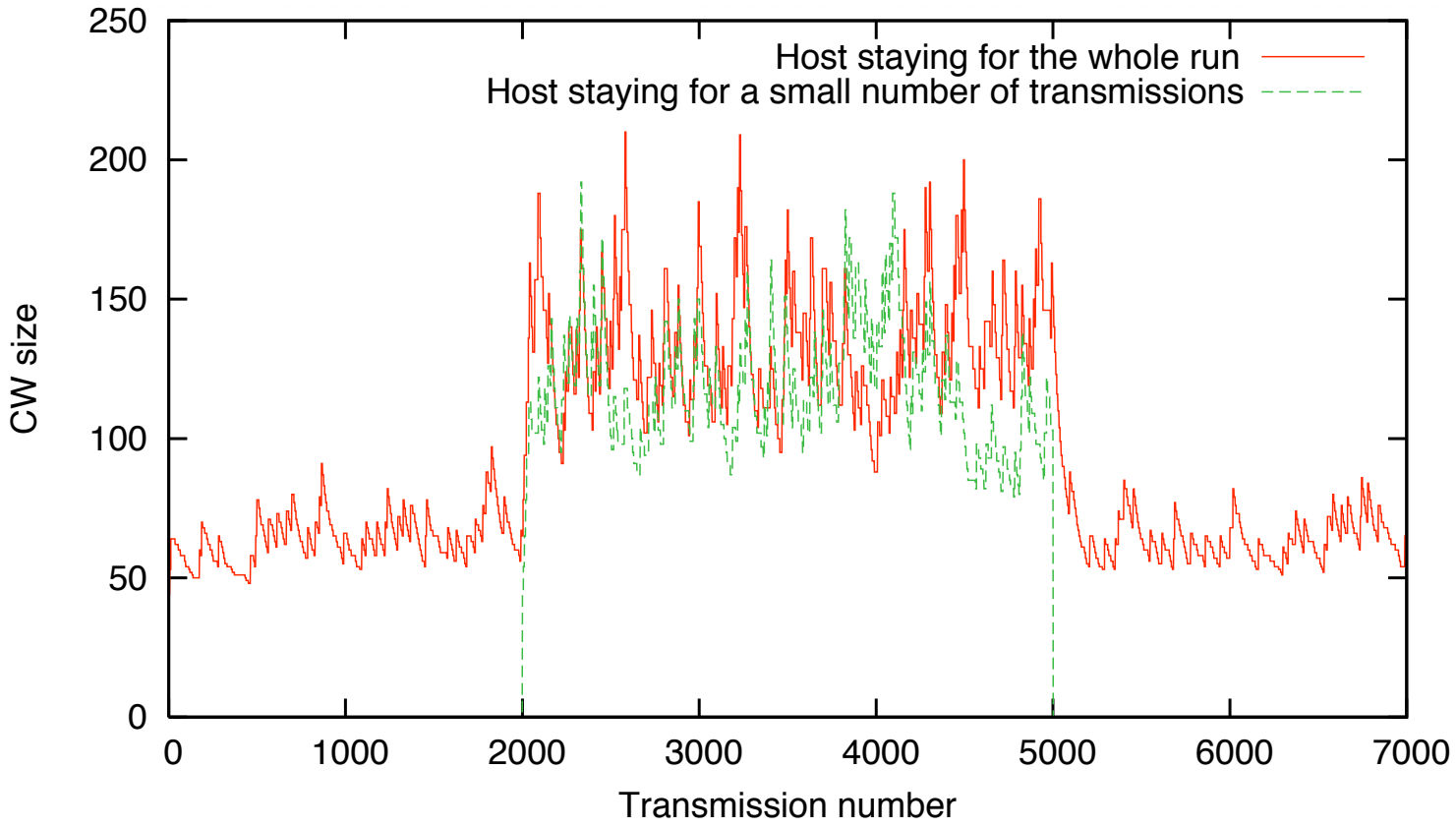

0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
Throughput (Mb/s)
20
40
60
80
100
120
140
160
180
200
N
802.11b
Idle Sense

Fairness

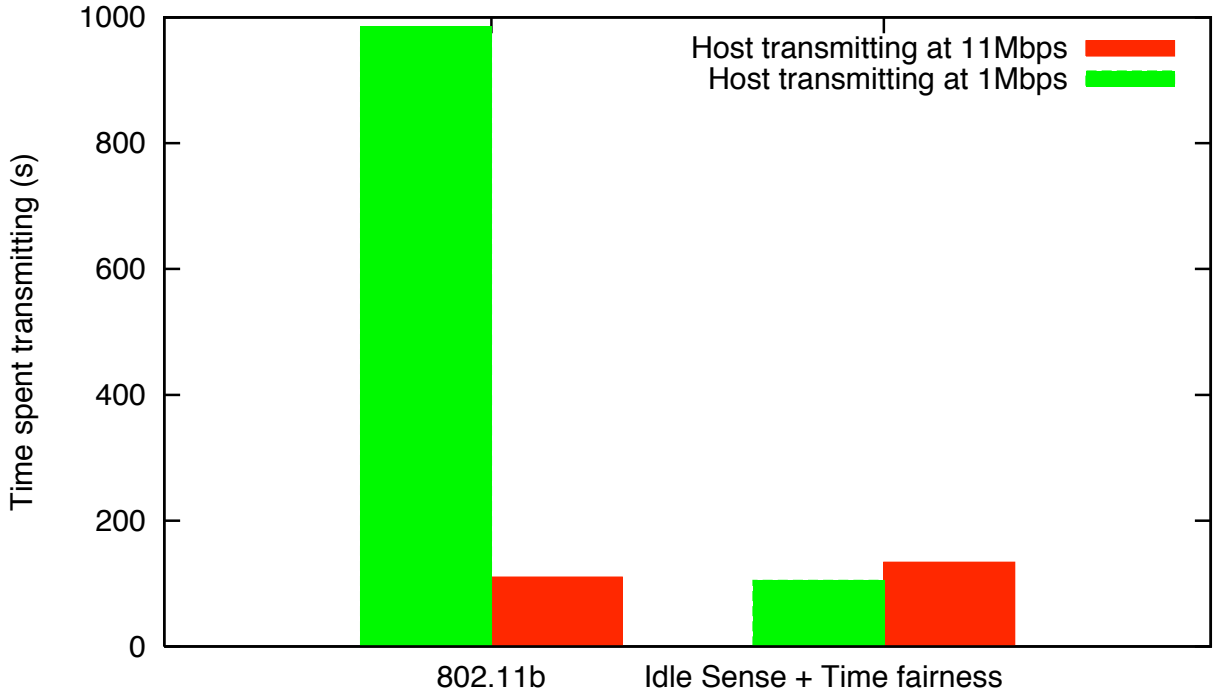
50 hosts



Convergence speed



Time fairness



Conclusions

- Performance gains
- Addresses many issues in wireless LANs
  - Main property: it uncouples frame loss and contention control
- Enables other improvements
  - eg. give more weight to the access point