Evaluating Wireless LAN Access Methods in Presence of Transmission Errors

IEEE INFOCOM 2006, Poster session

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Outline

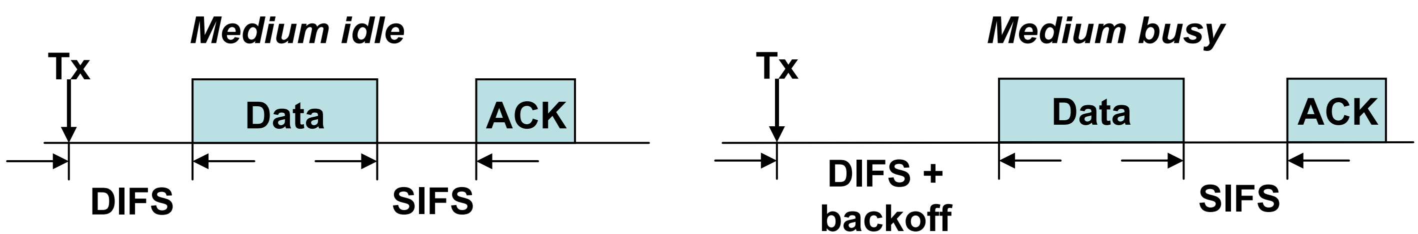
- Introduction
- Principles of chosen Access Methods
- Simulation environment
- System performance
- Conclusions

Introduction

- 1997: IEEE defines the first standard IEEE 802.11 for Wireless Local Area Networks
  - Successive variants have increased the nominal bit rate: IEEE 802.11 b/g/a
  - The MAC layer remains unchanged
  - Much research effort spent on improving MAC performance

Introduction

- IEEE 802.11 Distributed Coordination Function
  - Before initiating a transmission, a station senses the channel during a DIFS Time:
    - ✓ the medium is sensed idle → transmission allowed
    - ✓ the medium is sensed busy → next attempt of transmission at DIFS + backoff time
  - *Backoff time*: integer number of time slots distributed uniformly in [0, *CW*-1]
  - After each data frame succesfully received, the receiver transmits an ACK after a SIFS Time



Chosen Access Methods

- Different MAC proposals for improving IEEE 802.11 Wireless LANs
  - Slow Decrease
  - Asymptotically Optimal Backoff (AOB)
  - Idle Sense

Principles of chosen Access Methods

- *Slow Decrease*
  - Objective: adapting *CW* of each station to the current network congestion level
  - After each successful transmission:

$$CW_{new} = \max(CW_{\min}, 2^{-g} CW_{old})$$

  - the slowest decrease, which achieves the best performance, for
    - ✓ *g=1* $\rightarrow CW_{new} = 0.5 \cdot CW_{old}$
  - Preserves the exponential backoff mechanism of IEEE 802.11 DCF

Principles of chosen Access Methods

- *Asymptotically Optimal Backoff* (AOB)
  - Each host computes the *Probability of Transmission:*

$$PT = 1 - \min\left(1, \frac{SU}{SU_{opt}}\right)^{Na}$$

  - *Na*: Number of attempts for the transmission of a frame
  - *Slot Utilization (SU):*

$$SU = \frac{Num\_Busy\_Slots}{Num\_Available\_Slots}$$

  - If the transmission is rescheduled, a new backoff interval is computed
    - ✓ AOB preserves the exponential backoff mechanism of IEEE 802.11 DCF

Principles of chosen Access Methods

- *Idle Sense*
  - Each host estimates the number of consecutive *idle slots* between 2 transmission attempts
    - ✓ By comparing the estimate with a target value, hosts adjust their *CW* using *AIMD* principle
  - Contending hosts do not perform the exponential backoff mechanism of IEEE 802.11 DCF

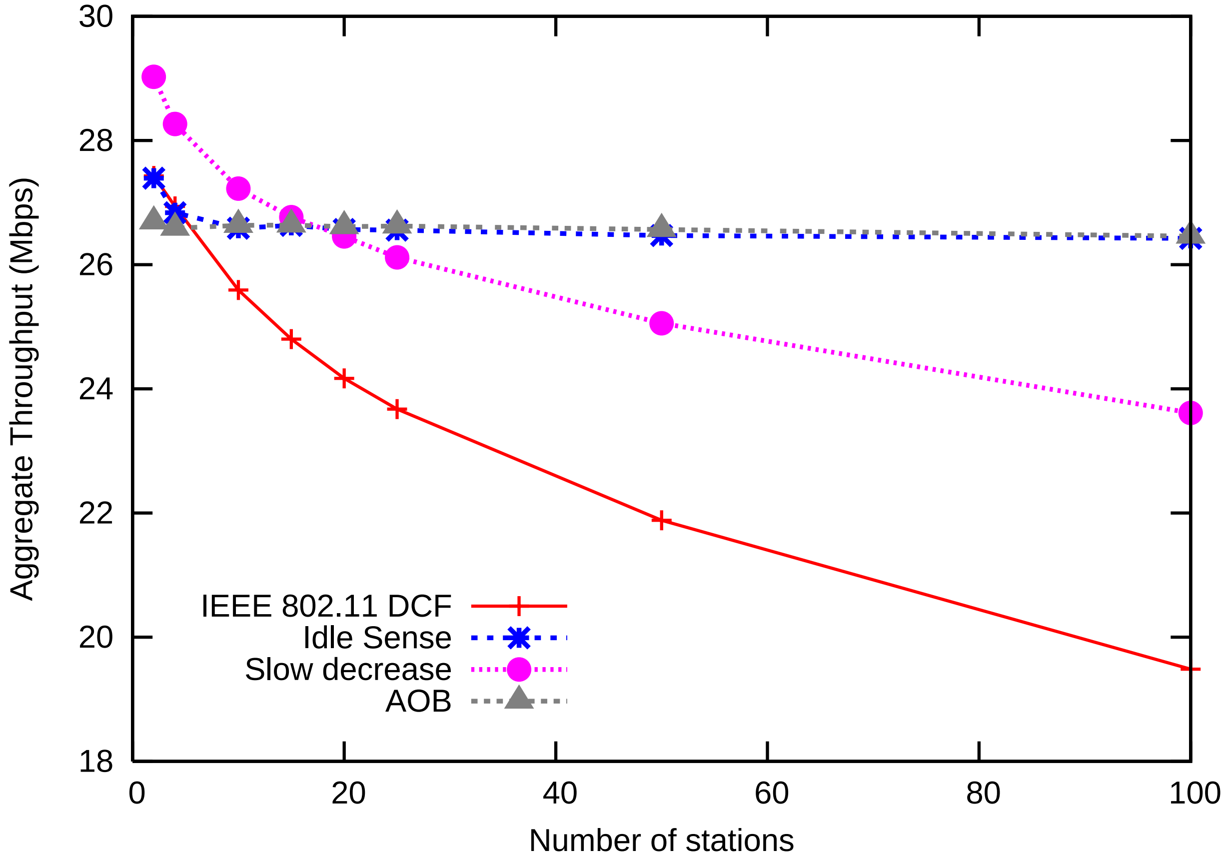
- Up to now, the different proposals have been compared under ideal channel conditions
  - Objective: Performance analysis of the different proposals in adverse transmission conditions

Simulation environment

- Simulation parameters
  - Physical layer of IEEE 802.11g
  - 1 BSS: every station subject to the same BER
    - $FER=1-(1-BER)^l$
    - *FER*: Frame error ratio; *l*: frame size in bits
  - Payload size of 1500 bytes and transmission rate of 54 Mbps
  - Greedy hosts

System performance

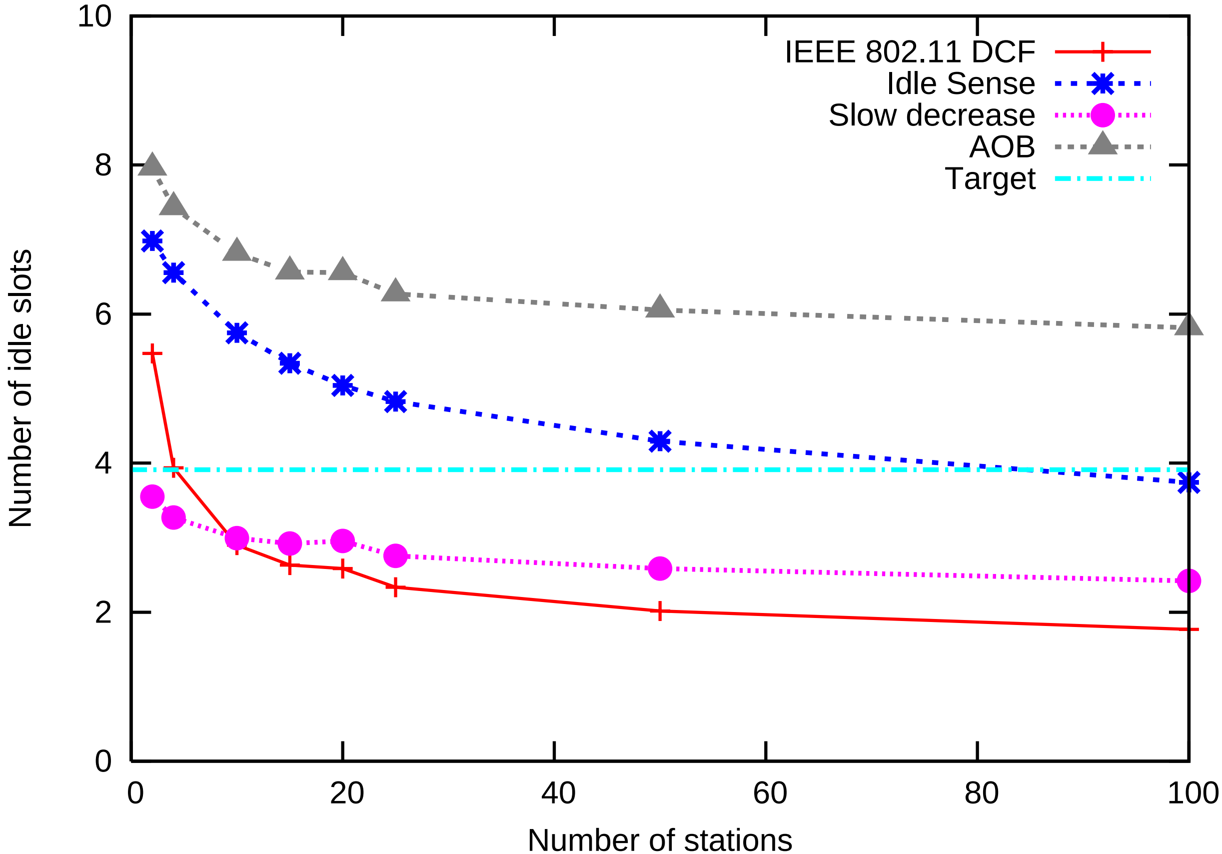
- Aggregate Throughput vs. number of stations
  - **BER=10^{-5}, FER$_{Data}$=12%, FER$_{ACK}$=0.65%**



- Throughput gain with Idle Sense (%):
  - ✓ 3.9 % for 10 stations
  - ✓ 35.6 % for 100 stations

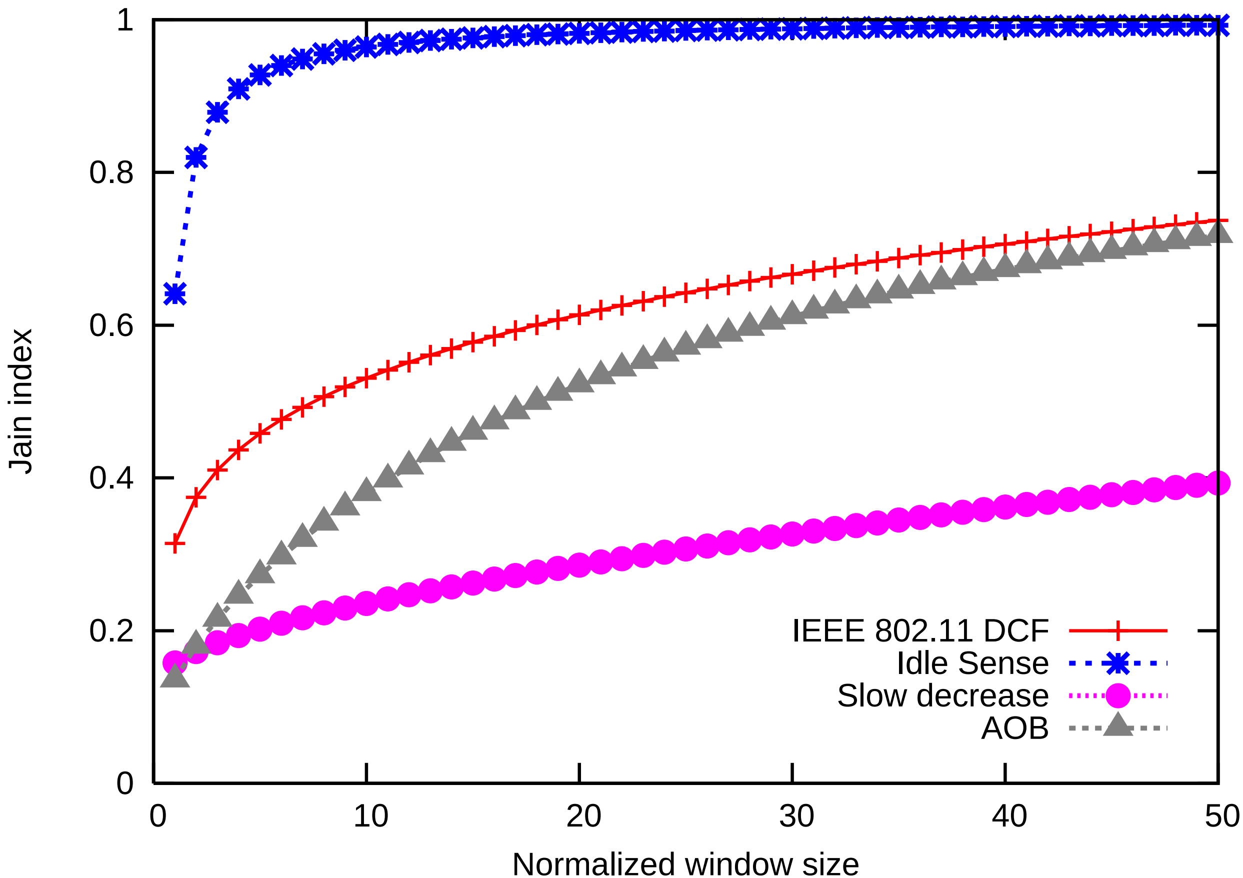
System performance

- Number of idle slots vs. number of stations
  - **BER=10^{-5}, FER$_{Data}$=12%, FER$_{ACK}$=0.65%**



System performance

- Channel Access Fairness: Jain Index
  - **Number of stations = 25, BER=10^{-5}, FER_{Data}=12%, FER_{ACK}=0.65%**

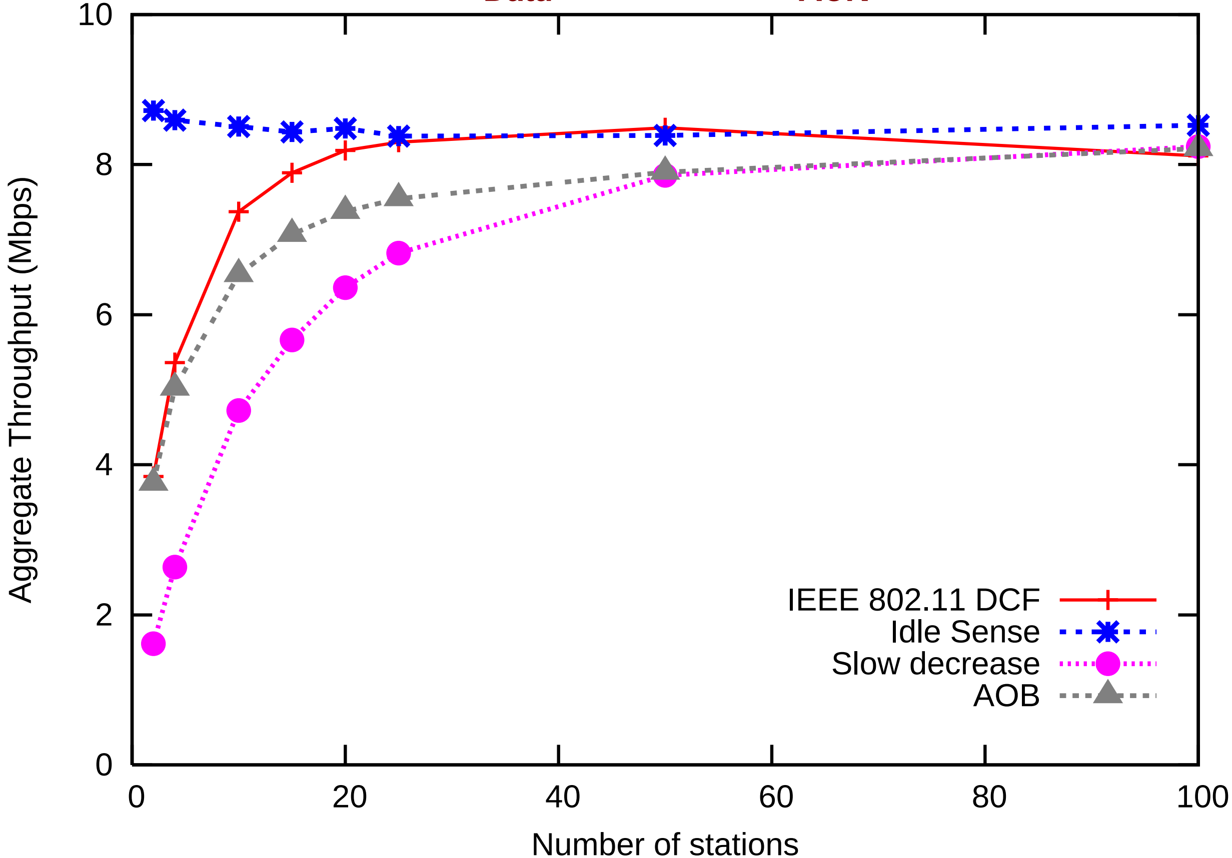


System performance

- *AOB* and *Idle Sense* provide significant improvement of the throughput performance
- *Idle Sense*
  - number of *idle slots* closer to the *target* than *AOB*
  - better *Channel Access Fairness*

System performance

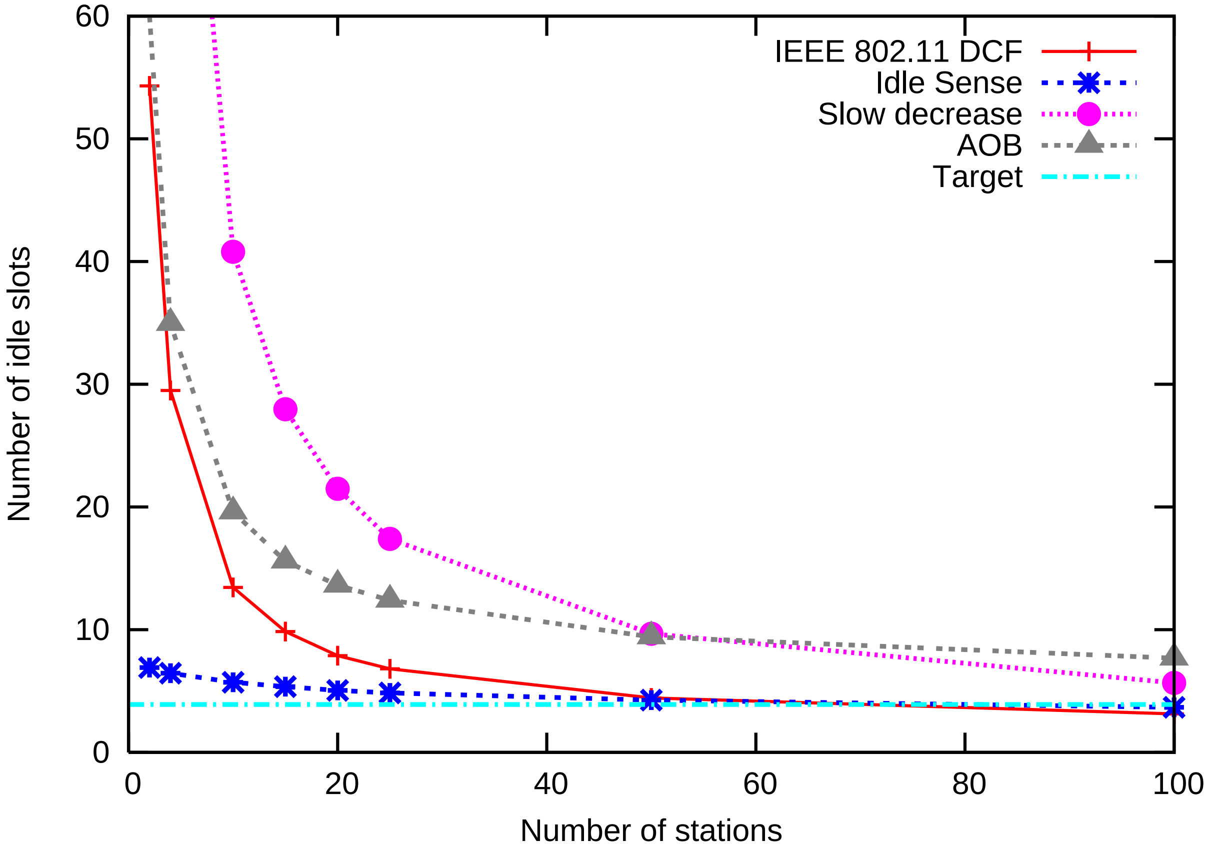
- Aggregate Throughput vs. number of stations
  - **BER=10^{-4}, FER$_{Data}$=72%, FER$_{ACK}$=6.4%**



- Throughput gain with Idle Sense (%):
  - ✓ 127 % for 2 stations
  - ✓ 60.3 % for 4 stations
  - ✓ 15.4 % for 10 stations
  - ✓ 3.6 % for 20 stations

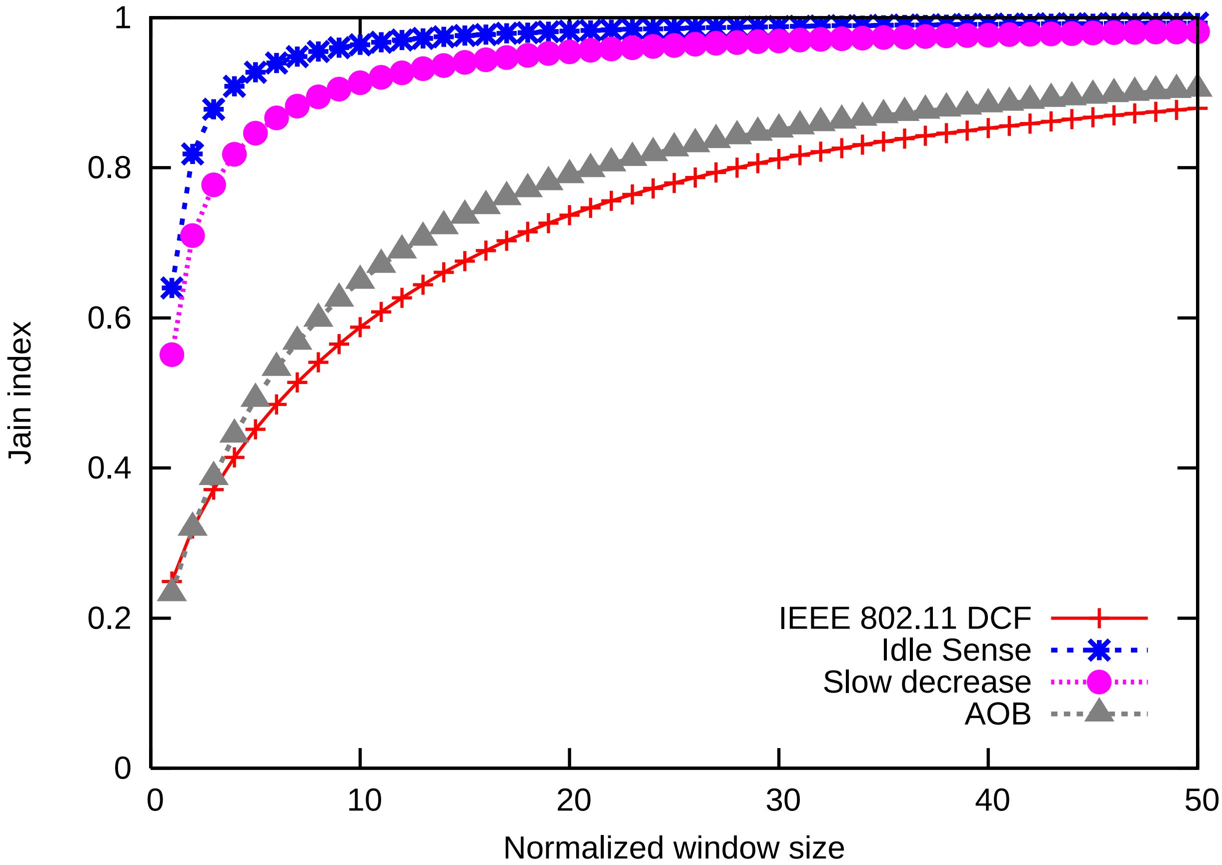
System performance

- Number of idle slots vs. number of stations
  - **BER=10^{-4}, FER$_{Data}$=72%, FER$_{ACK}$=6.4%**



System performance

- Fairness: Jain Index
  - **Number of stations = 25, BER=10^{-4}, FER_{Data}=72%, FER_{ACK}=6.4%**



System performance

- *Idle Sense*
  - the best overall throughput performance
  - number of *idle slots* closer to the *target*: it does not perform the *exponential backoff algorithm*
  - better *Channel Access Fairness*
- *Slow Decrease* and *AOB*:
  - do not improve the IEEE 802.11 DCF performance
  - perform the exponential backoff after collisions and frames losses

Conclusions

- Evaluation of different MAC proposals for IEEE 802.11 Wireless LAN in adverse transmission conditions
  - Slow Decrease
  - Asymptotically Optimal Backoff
  - Idle Sense
- Idle Sense does not use the *exponential backoff algorithm*
  - number of *idle slots* closer to the target value
  - higher throughput
  - better channel access fairness
- Next steps
  - Cells composed of stations subject to different BER values
  - Stations working at different transmission rates
  - Multicell environments