
Evaluating Wireless LAN Access Methods in Presence of Transmission Errors

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LSR-IMAG



Outline

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

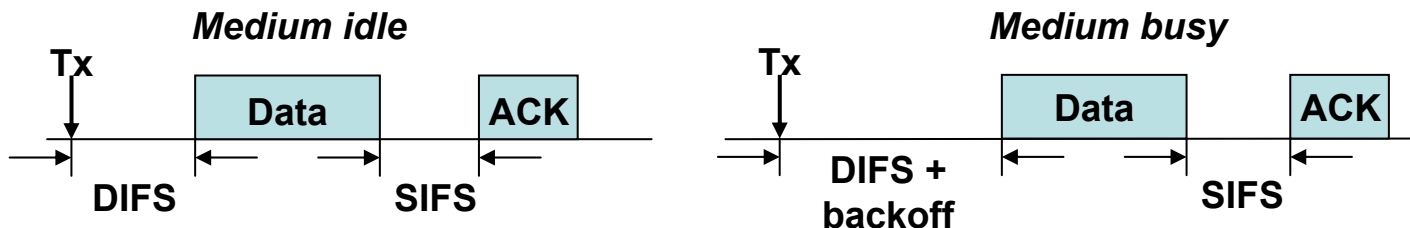
Introduction

- 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 successfully 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)*:

$$SU = \frac{\text{Num_Busy_Slots}}{\text{Num_Available_Slots}}$$

- 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

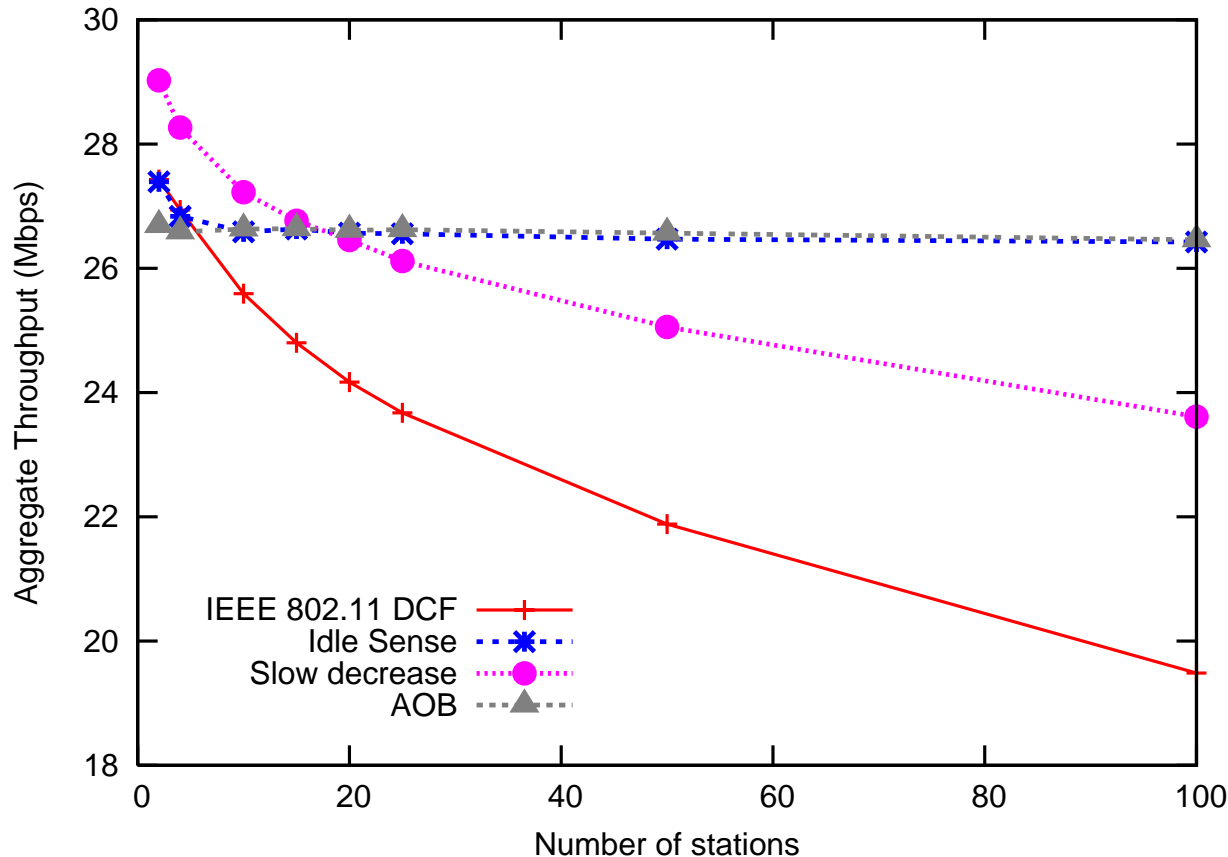
- Simulation parameters

- 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 (%):

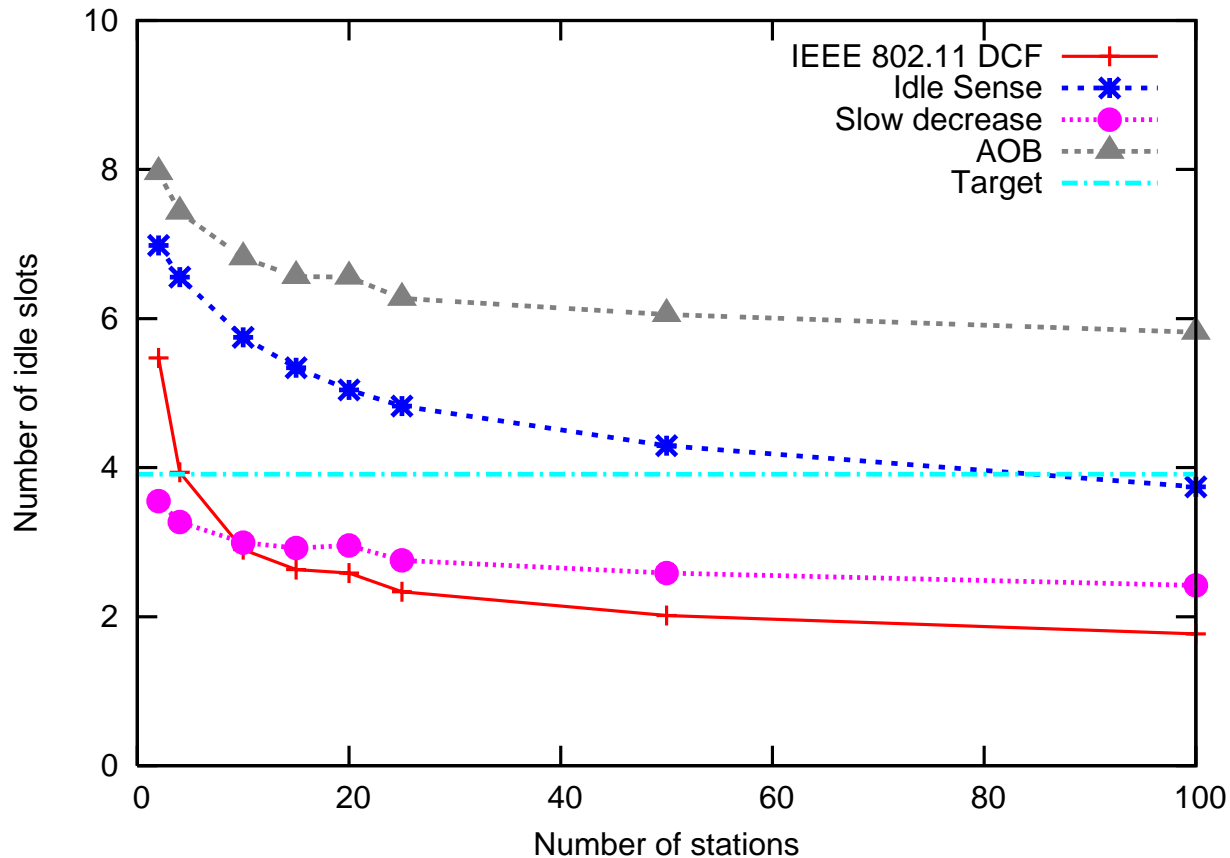
✓ 3.9 % for 10 stations

✓ 35.6 % for 100 stations

System performance

- Number of idle slots vs. number of stations

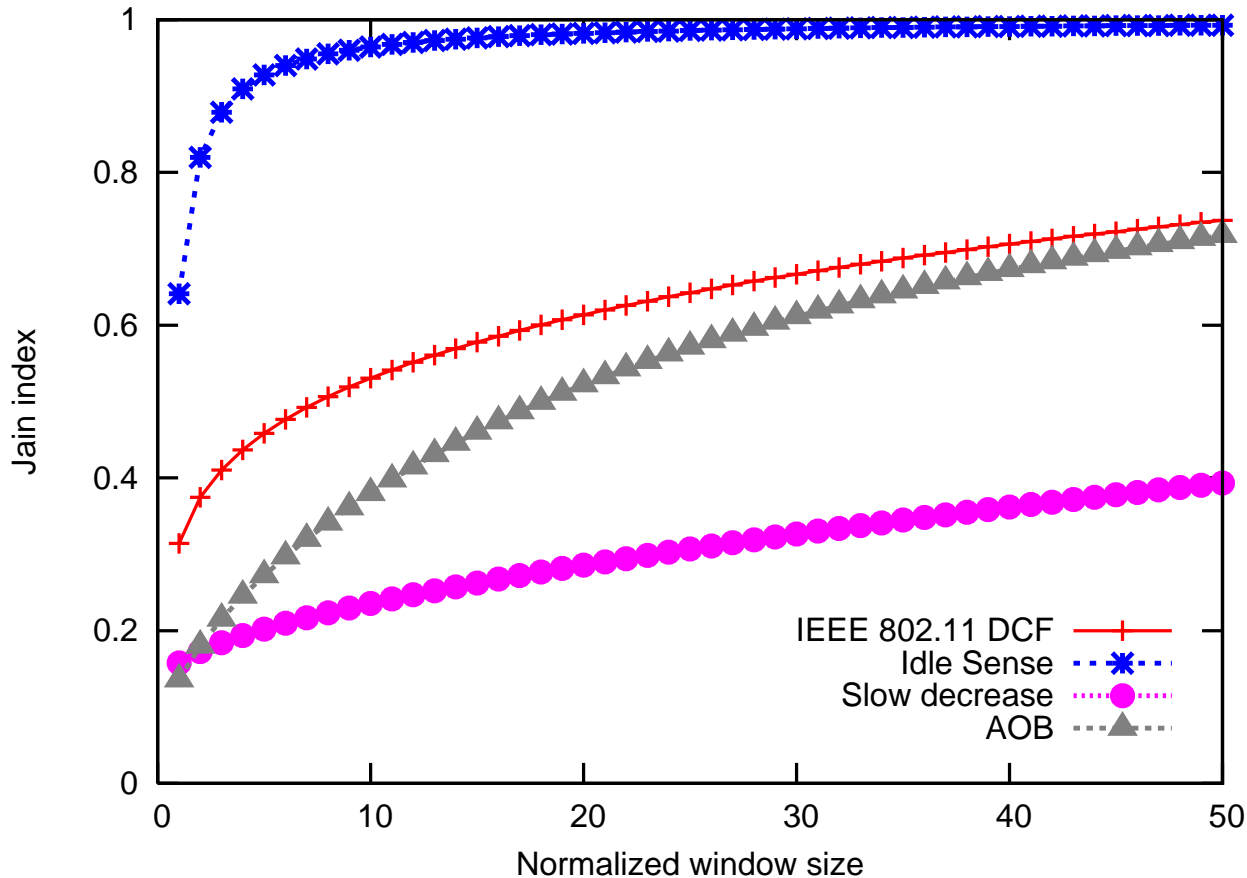
➤ **BER=10⁻⁵, FER_{Data}=12%, FER_{ACK}=0.65%**



System performance

- Channel Access Fairness: Jain Index

➤ **Number of stations = 25, BER=10⁻⁵, FER_{Data}=12%, FER_{ACK}=0.65%**



System performance

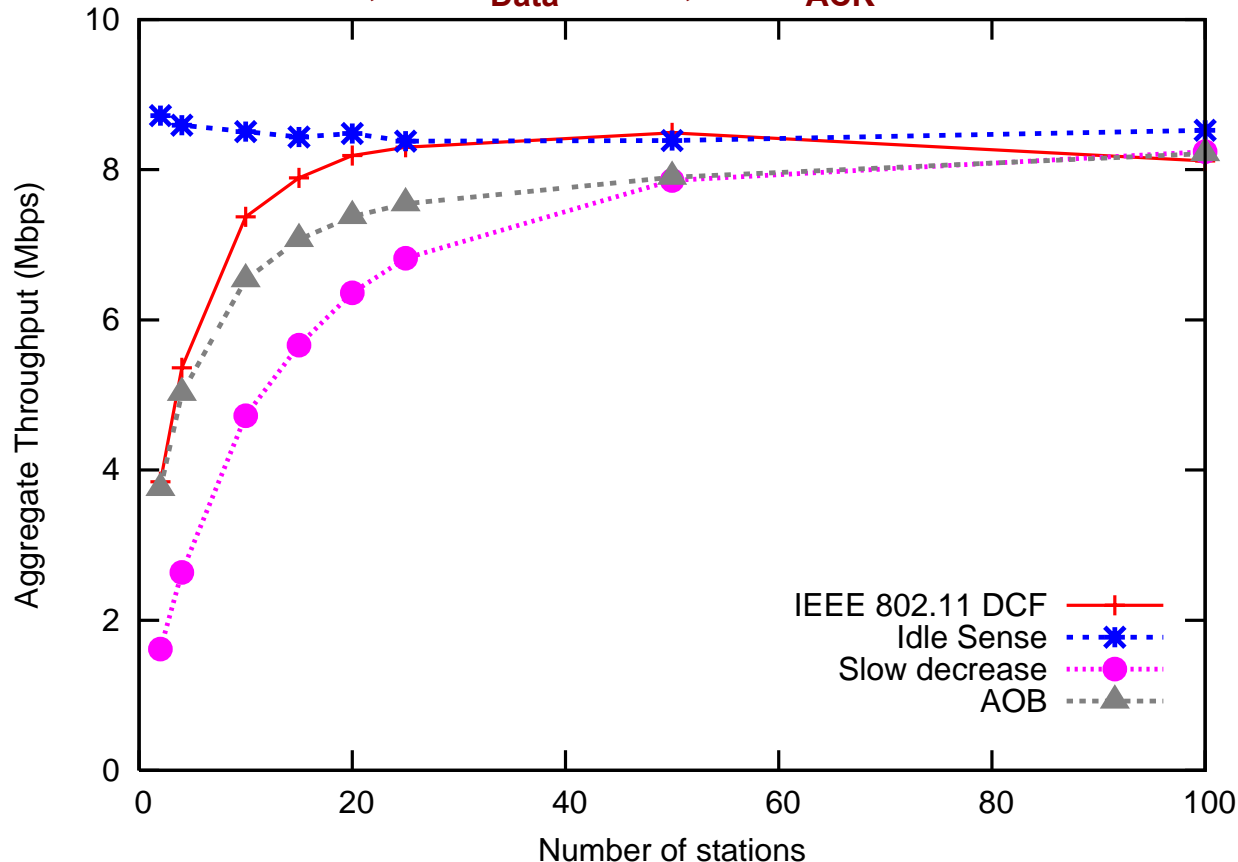
- *AOB* and *Idle Sense* provide significant improvement of the throughput performance
- *Idle Sense*
 - number of *idle slots* closer to the *target* than *AOB*
 - better *Channel Access Fairness*



System performance

Aggregate Throughput vs. number of stations

➤ **BER=10⁻⁴, FER_{Data}=72%, FER_{ACK}=6.4%**



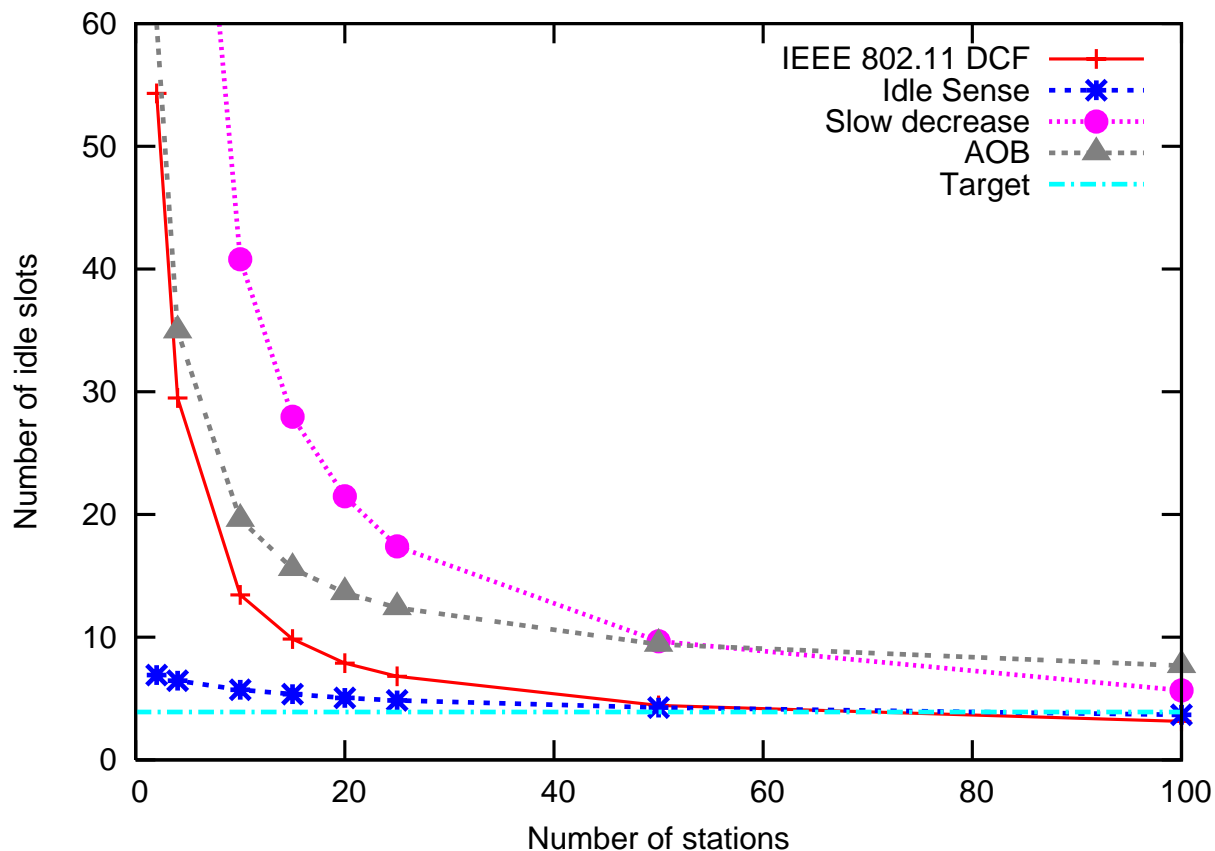
➤ Throughput gain with Idle Sense (%):

- ✓ 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

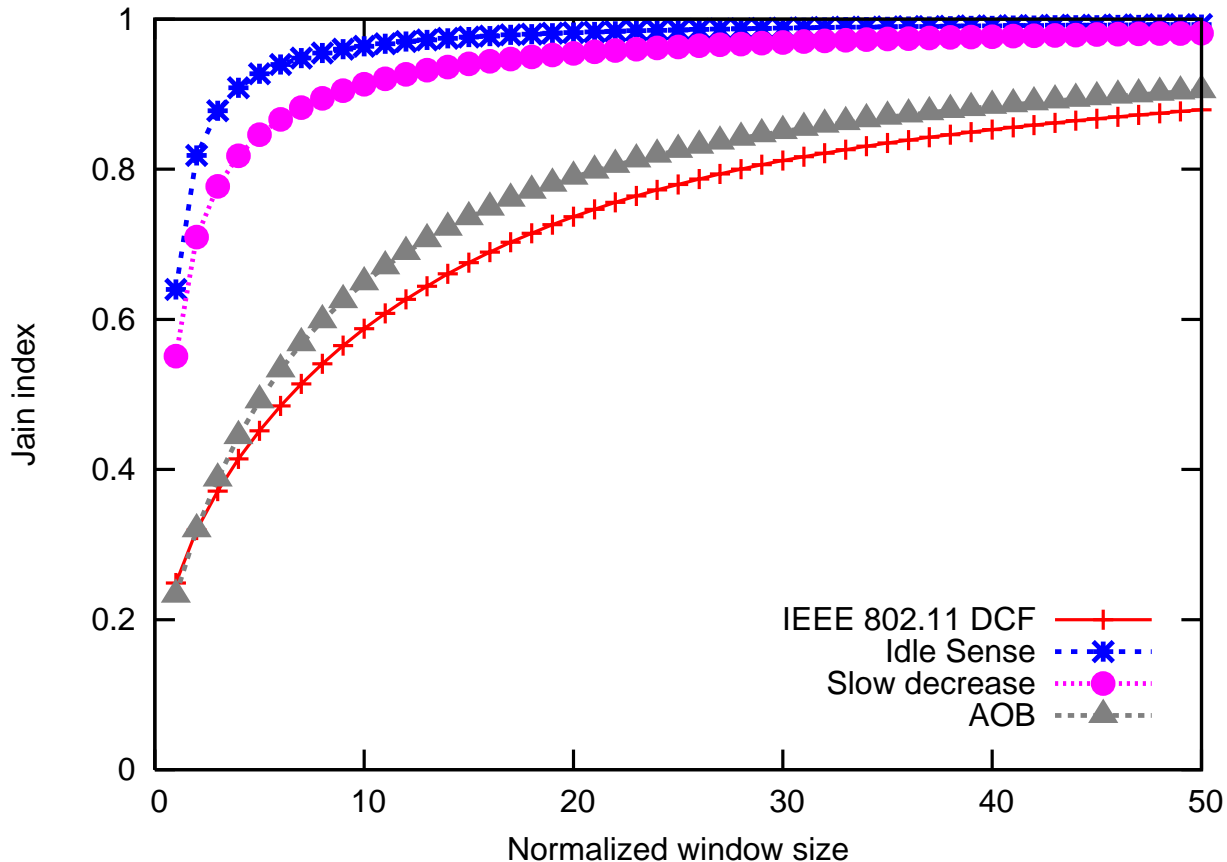
➤ **BER=10⁻⁴, FER_{Data}=72%, FER_{ACK}=6.4%**



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