Evaluating Wireless LAN Access Methods in Presence of Transmission Errors

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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 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

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LSR-IMAG 8
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_{\text{Data}}=12\%, FER_{\text{ACK}}=0.65\%**

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

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IEEE 802.11 DCF
Idle Sense
Slow decrease
AOB
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=$10^{-4}$, $\text{FER}_{\text{Data}}=72\%$, $\text{FER}_{\text{ACK}}=6.4\%$

  - 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
  - $\text{BER}=10^{-4}$, $\text{FER}_{\text{Data}}=72\%$, $\text{FER}_{\text{ACK}}=6.4\%$

![Graph showing number of idle slots vs. number of stations](image)
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