Simulation of 802.11 PHY/MAC: the Quest for Accuracy and Efficiency

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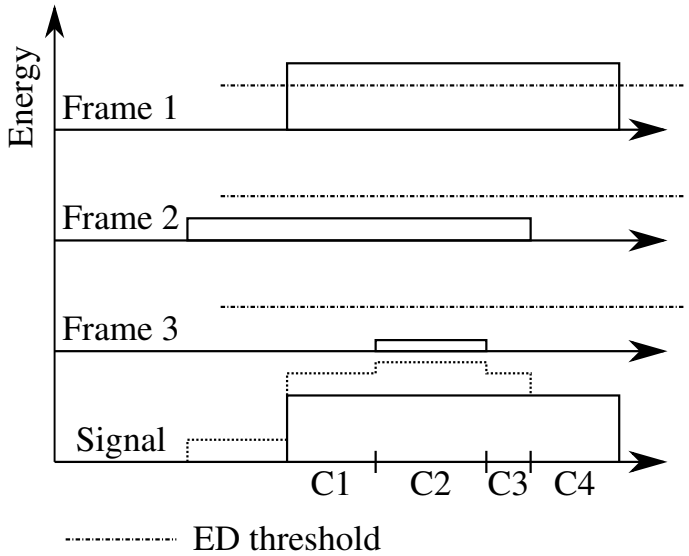
Reasons Of This Work

- Need of realistic and scalable simulations for VANETs
- ns-3 choices:
  - ns-3 default PHY layer (YANS)
    - Stochastic
    - Scalable
    - Lack of realism
  - PhySim implementation by DSN Research Group (KIT)[1]
    - Emulative
    - Not scalable
    - Highly realistic
- Other popular simulators:
  - ns-2
  - Omnet++
- None consider shadowing due to obstacles
- **Goal:** provide a scalable model accurate enough for VANET simulations

ns-3 Models' Description

YANS - Stochastic model

- Chunk based with BER/PER approach

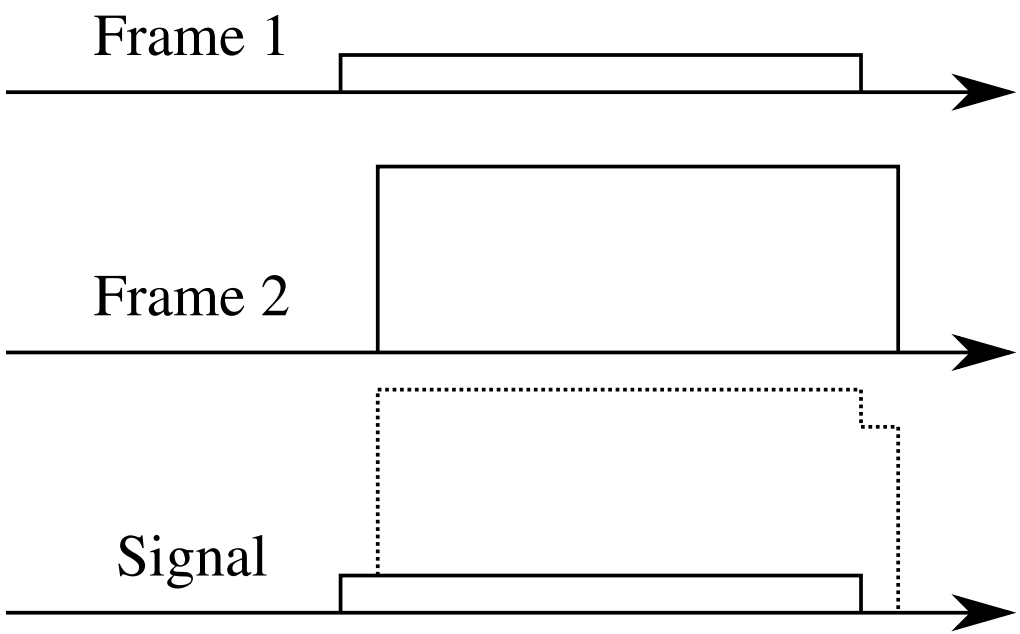


- Frame received with probability

$$P_r(f) = \prod_{c_i \in f} 1 - P_e(c_i).$$

YANS - Stochastic model

- Optimistic (recently, error rate model updated by NIST)
- Preamble / header decoding phases missing
- No capture effects
- Fading model (i.e., Nakagami) does not consider relative speed



PhySim - Emulative model

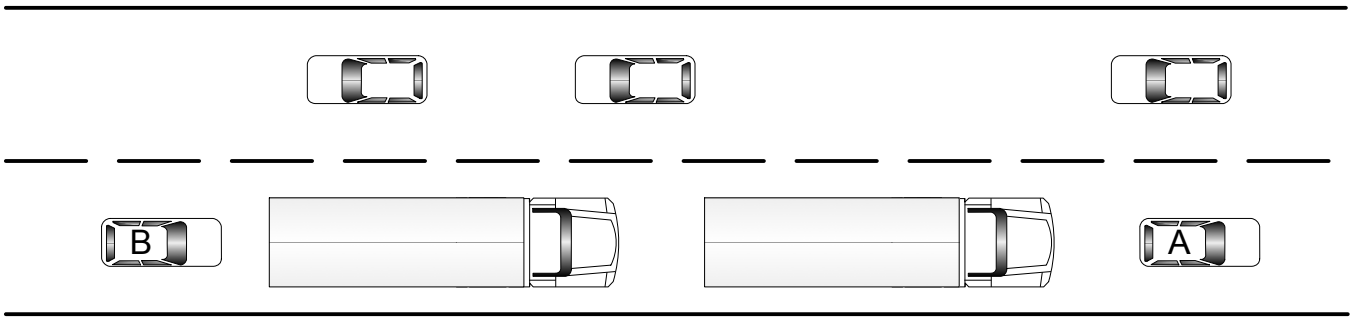
- Emulative - DSP oriented approach
- Bits -> Scrambling -> Conv. encoding -> Interleaving -> Modulation -> IFFT -> GI -> Samples
- Signal represented as complex time samples
- Channel represented through tapped delay line
- TDL setup using data from real traces for realistic fading
- Drawback: traces are relative to a fixed scenario

PhySim - Emulative model

- Reception = reverse send procedure:
  - Try to detect preamble and estimate freq. offset
  - Try to decode the PLCP header
  - Try to decode the payload
- Natural reproduction of real phenomena
- High realism
- Huge computational load

A note on shadowing

- Shadowing: additional attenuation caused by obstacles
- Usually modelled using random fluctuations of signal energy
- What about this case?



- A single truck can cause 20 dB of attenuation (Meireles et. al., "Experimental study on the impact of vehicular obstructions in VANETs", VNC 2010)

Proposed Approach

Idea: Markov Decision Process

- Create a MDP for the PHY receive procedure
- Tune it with results obtained through PhySim
- Important parameters:
  - Current reception phase:

$$R_P = \{\text{Preamble}, \text{Header}, \text{payLoad}\}$$

  - Vector of interfering frames $\vec{I}$

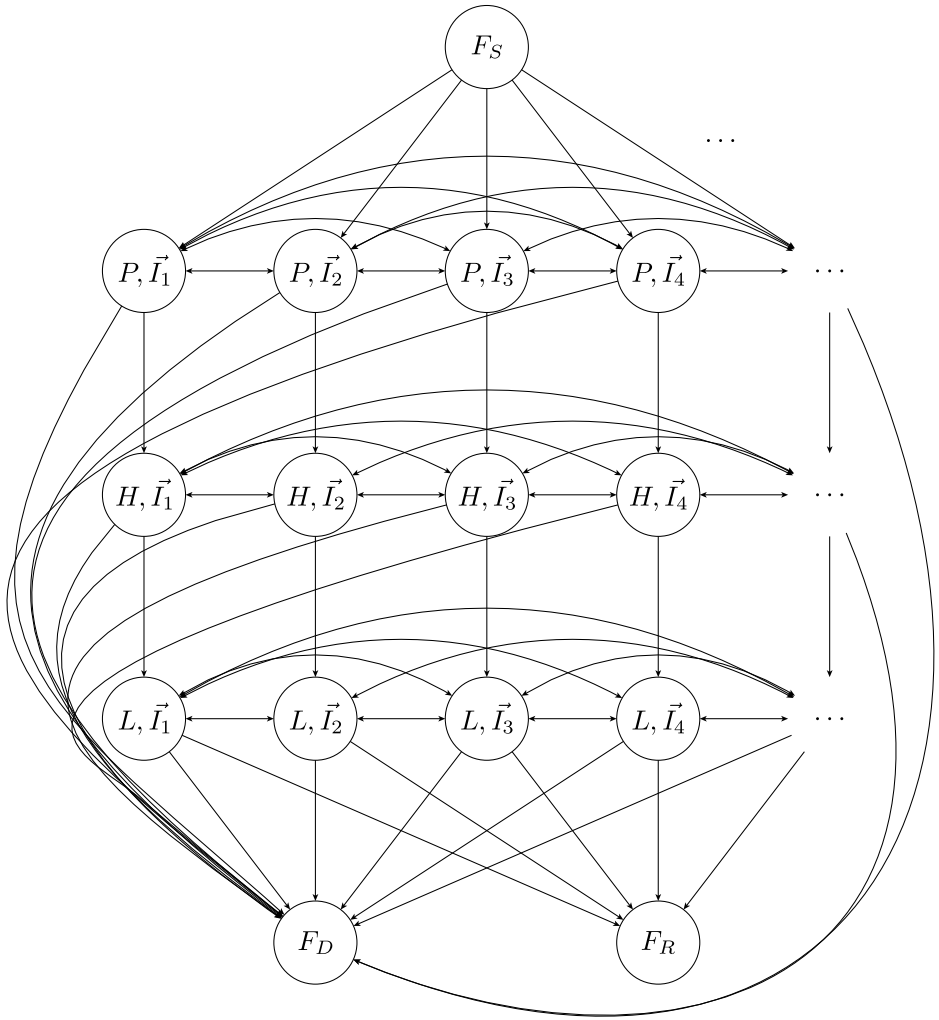
$$\mathcal{F} \in \vec{I} = (t_s, t_e, PW, B, \Delta_f, MC, \Delta_v)$$

  - Frame under reception (described as any other frame $\mathcal{F}$)
- The state $\mathcal{S}$ of the MDP is

$$\mathcal{S} = \{F_S; F_R; F_D; (R_P, \vec{I}), E\}$$

where F_S = initial state, F_R/F_D = absorbing states for receive/discard decision, E = environment

MDP Graphical Representation

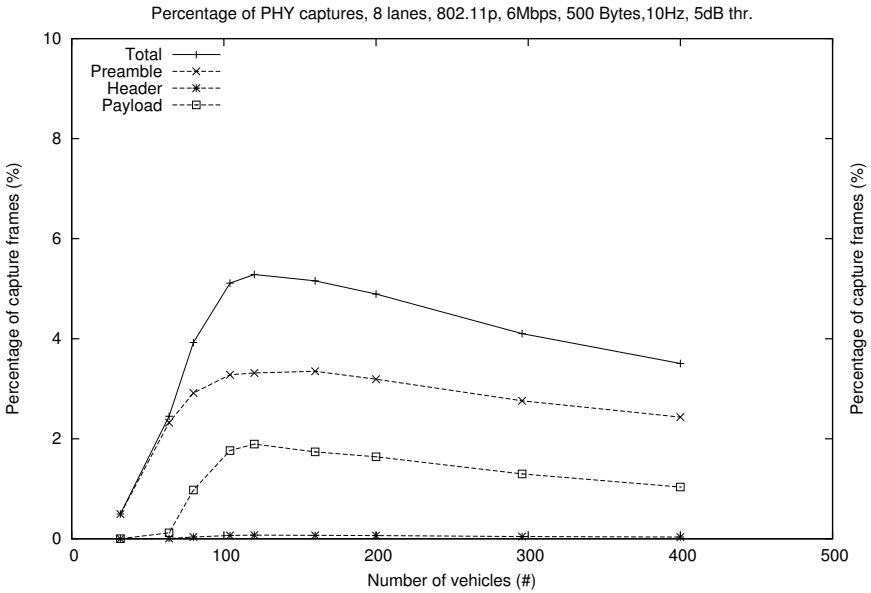


First implementation

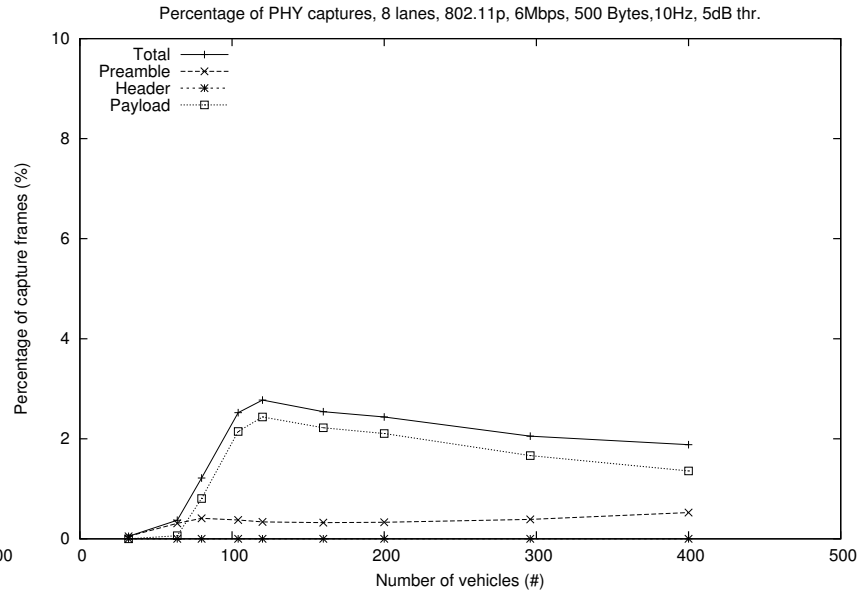
Features:

- PHY state machine with captures
- Simple environment description (cars and trucks) for shadowing effects
- Uses the NIST BER model

Fraction of frames generating a capture, 5 dB thr.



ED thr. = -104 dBm, Preamble BUSY over -65 dBm



ED thr. = -85 dBm, Preamble BUSY over -85 dBm

Impact of trucks on frame reception

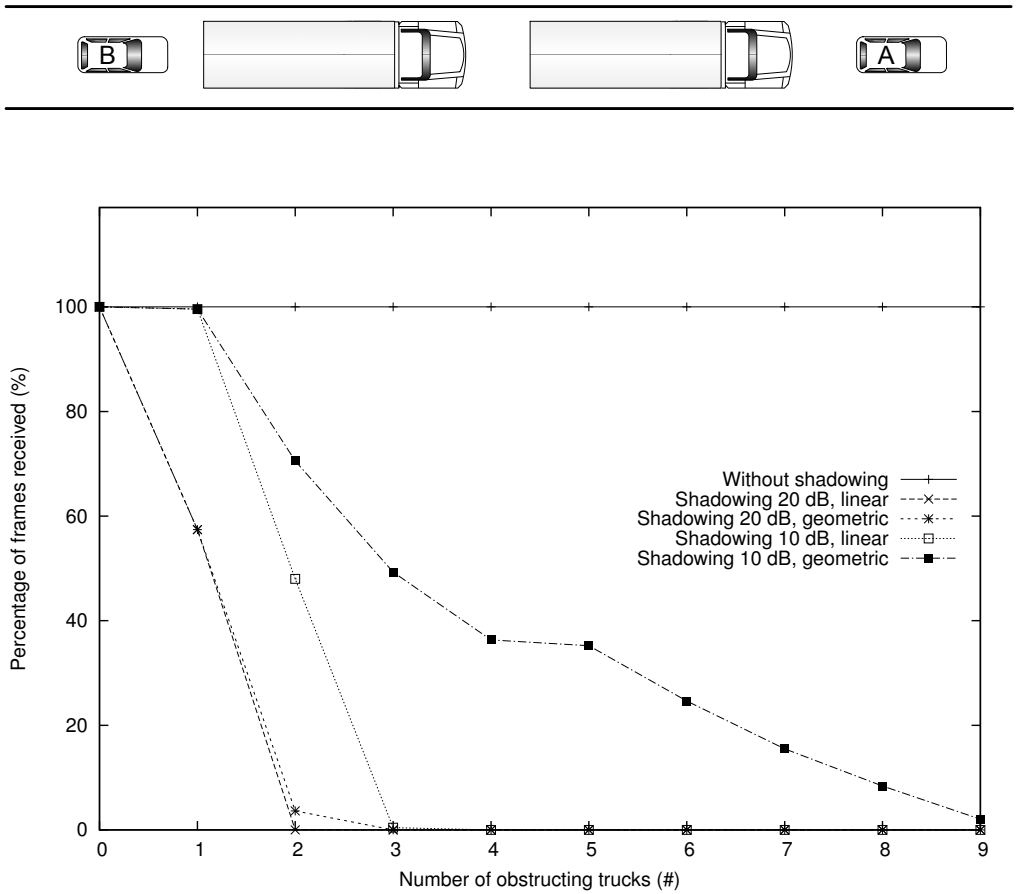


Figure: Payload 500 bytes, data rate 6 Mbps

Impact of relative speed

Work in progress. Can take 1 hour to process 100-200 frames

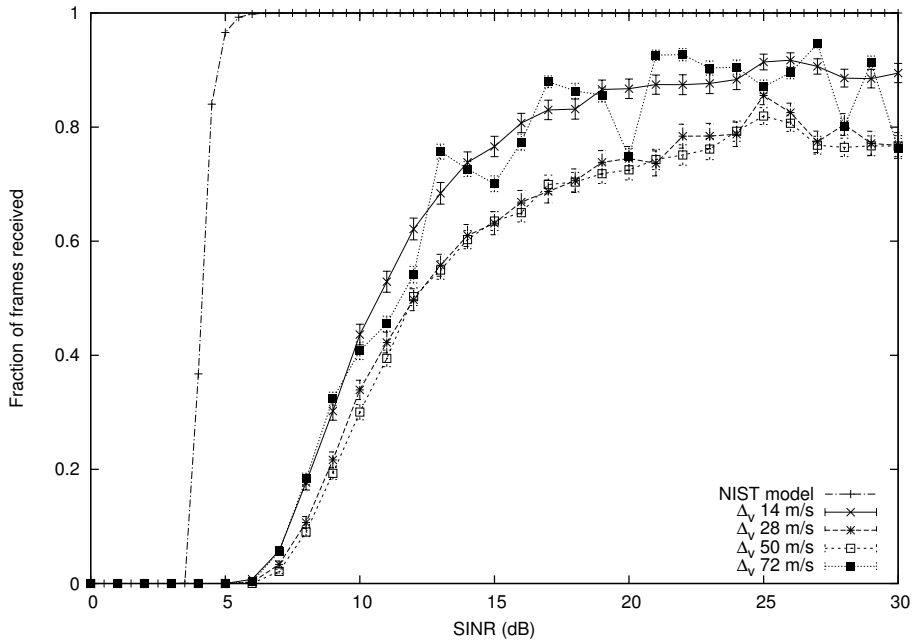


Figure: Payload 500 bytes, data rate 6 Mbps

Conclusion

- Currently available stochastic models are not precise enough for VANETs (PHY, fading, shadowing)
- A DSP-like approach harms scalability, but is useful for understanding and model derivation
- An MDP-like approach with enough information can improve precision

That's all!
Thanks for listening!
Questions?

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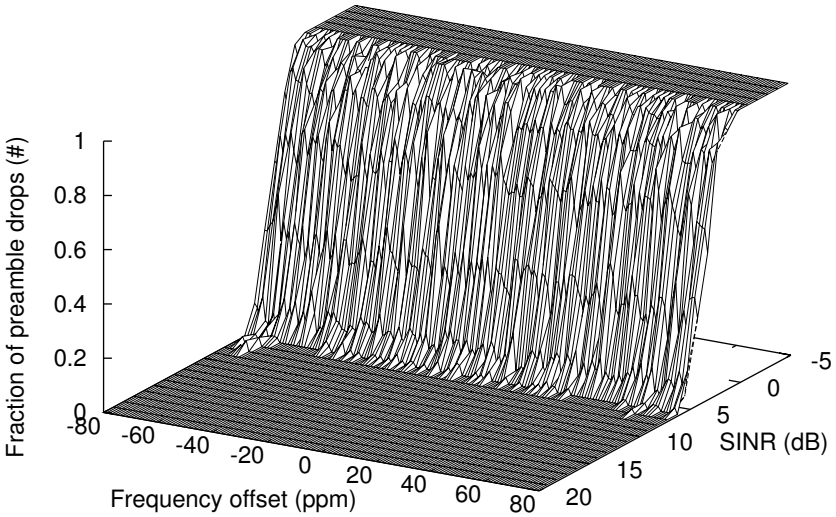
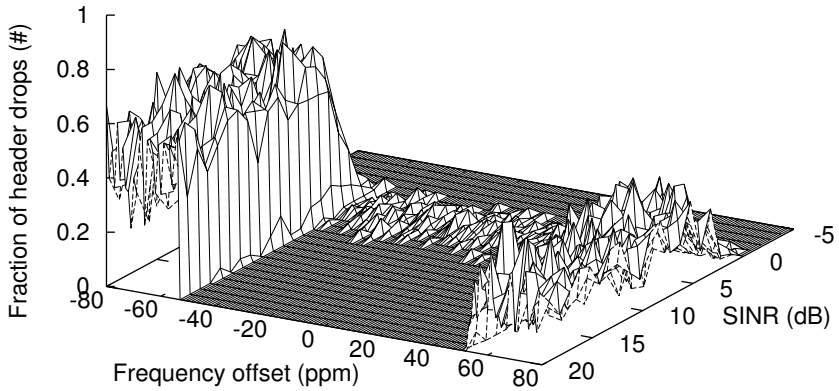
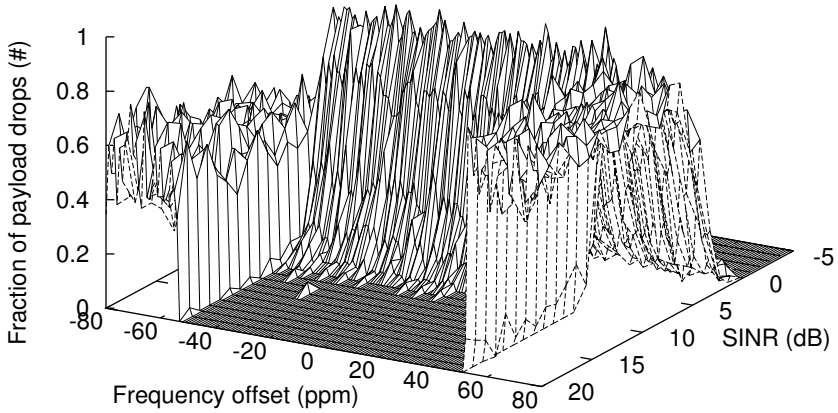
Δ_f effects on preamble, header and payload







PHY layer behavior – Noise floor only