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# **An Enhanced AODV Protocol for VANETs with Realistic Radio Propagation Model Validation**



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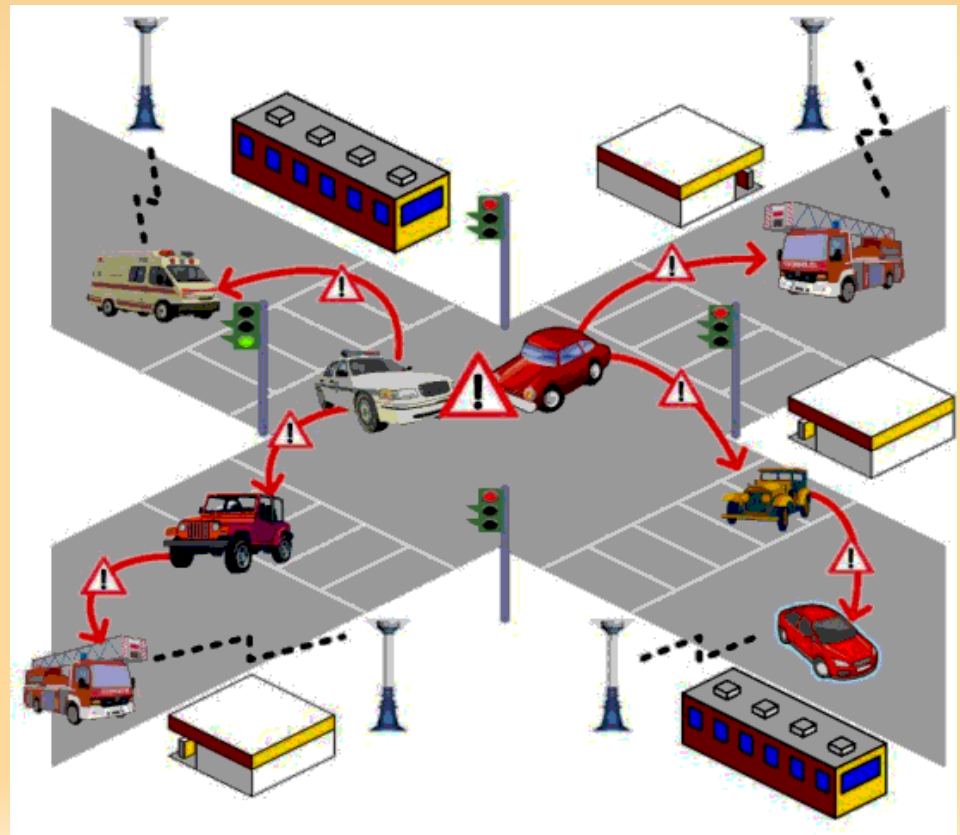
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1. Context and Introduction
2. Contribution: V-AODV
3. Comparative Evaluation of AODV and V-AODV
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# 1. Context

## Vehicular Ad-hoc NETWORKs (VANETs)

- From Infrastructure to Ad-Hoc Networks
- From MANETs to VANETs



*An example of VANET*

# 1. Introduction

## Main Concern: Unstable Topology

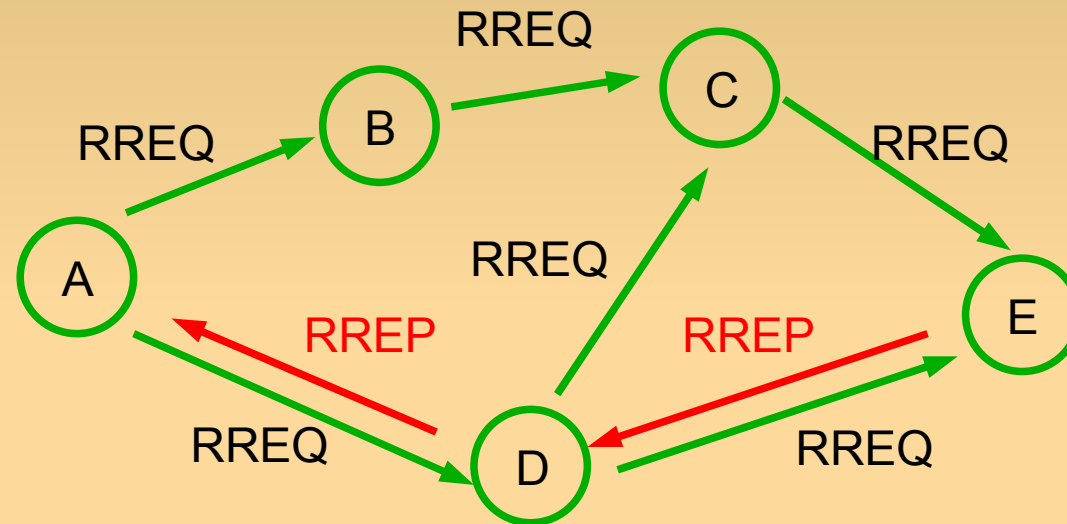
### Broken Routes:

- Fading
- Time variation
- Nodes mobility
- Multi-paths effects

## Main Challenge in VANETs: QoS

# 1. Introduction

## AODV



*How AODV creates a route between nodes A and E via Route Request and Route Reply.*

Problem: Protocol Based on Number of Hops, without Quality Of Service.

# 2. V-AODV

## QoS in AODV Routing Protocol

### QoS Metrics:

- Bandwidth
- Delay
- Bit Error Rate (BER)
- Packet Loss Probability
- Security
- etc...

In our work, we focused on Delay and BER parameters.

## 2. V-AODV

# QoS in AODV Routing Protocol

### Delay

The delay cost function of a node  $i$  :

$$c_d = \frac{D_{i,j}}{D_{\max} - \sum_{i=1}^j D_i}$$

Where :

$D_{i,j}$  : the estimated delay to the next hop,

$D_{\max}$  : the limit bound of delay supported by a flow,

$\sum_i^D$  : the accumulated delay from the source “i” to the destination “j”.

## 2. V-AODV

# QoS in AODV Routing Protocol

### BER

BER cost function :

$$C_{BER} = \frac{1}{BER_{max} - BER_{estimated}}$$

### BER + Delay

Total cost function :

$$C_{ETE} = \frac{1}{BER_{max} - BER_{estimated}} + \frac{D_{i,j}}{D_{max} - \sum_{i=1}^j D_i}$$



# 2. V-AODV with Standard Propagation Model

## Simulation Parameters

- Network Simulator -Ns-2
- FreeSpace Propagation Model
- 10 Nodes
- 3 Communications
- Same Mobility for all Simulations

## All simulations on Linux

- Core2Duo
- RAM: 4 Go

## 2. V-AODV with Standard Propagation Model

Different Protocols ... approximately the same results

Protocol	AODV-Standard	V-AODV-Delay
Average End-to-End Delay	0,00331	0,00348
Average Nbr of Hop	1,000	1,000
Average Packets Drop	0,000	0,000

- No packets loss,
- Very good end-to-end delay,
- Only one hop between source and destination...

**All seems to be perfect !**

Let us make the same simulations with another propagation model.

# 2. V-AODV with Realistic Propagation Model

## Ns2 Propagation Model

- FreeSpace
- Two Ray Ground

## Communication Ray Tracer Propagation Model (CRT)

- Ray Tracer Model
- Error Model based on BER for each link
- BER parameter is added to every packet transmitted

$$PER = 1 - (1 - BER)^N$$

The Signal to Noise Ratio (SNR) given by CRT is used to calculate the BER which gives the Packet Error Rate (PER) of each link.

# 2. V-AODV with Realistic Propagation Model



FreeSpace Propagation Model

CRT Propagation Model

*A realistic environment: the Munich City Center*

# 3. V-AODV Evaluation

Performance evaluation parameters used to measure the performance of AODV and V-AODV routing protocols.

*Average end-to-end delay (AEED)*

*Packet Delivery Ratio*

$$PDR = \frac{\text{Number of successfully Delivered Packets}}{\text{Total Number of transmitted Packets}}$$

*Normalized Oversized Load*

$$NOL = \frac{\text{Total Number of Routing Packets}}{\text{Number of Successfully Delivered Packets}}$$

# 3. V-AODV Evaluation

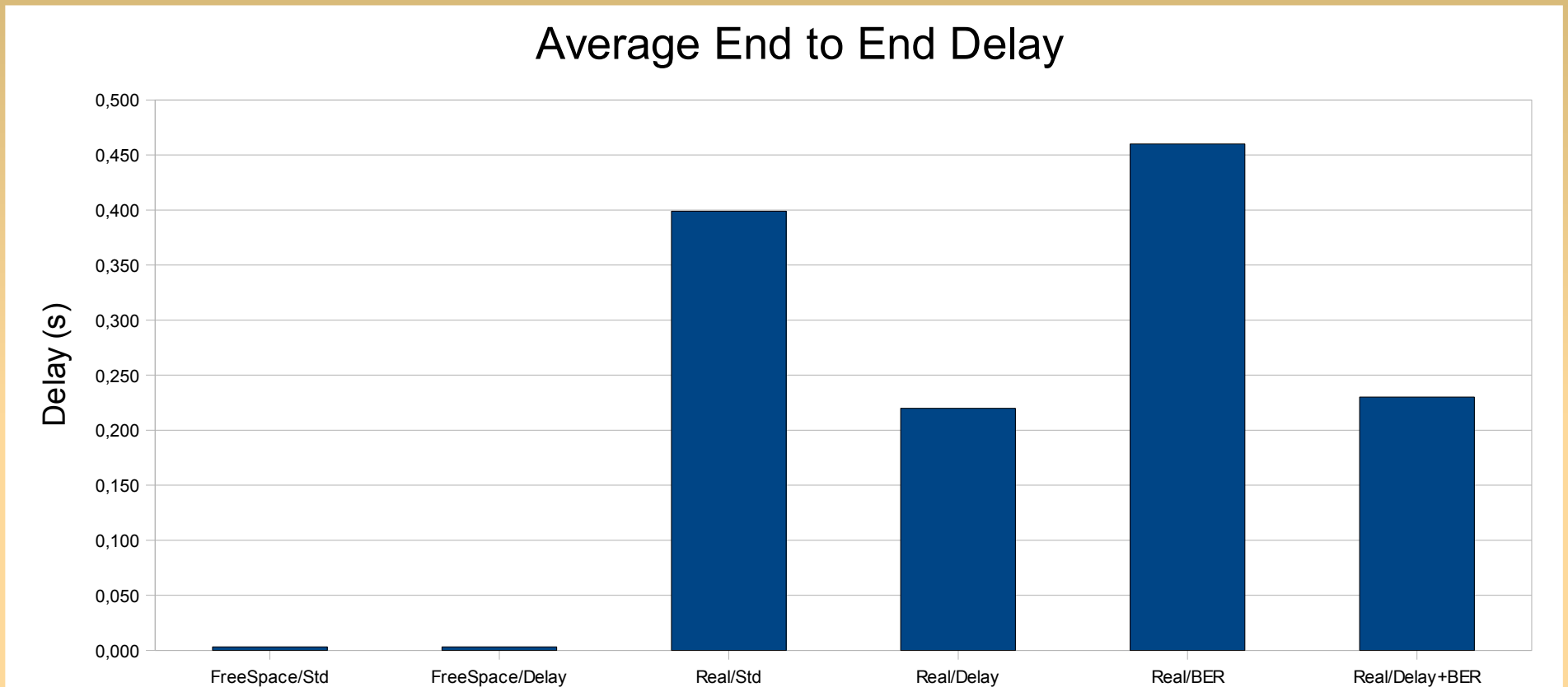
## 4 Different Protocols

- AODV Standard
- V-AODV (Delay)
- V-AODV (BER)
- V-AODV (Delay+BER)

## 2 Different Propagation Models

- Standard Ns2 Free Space Model
- Realistic CRT Model

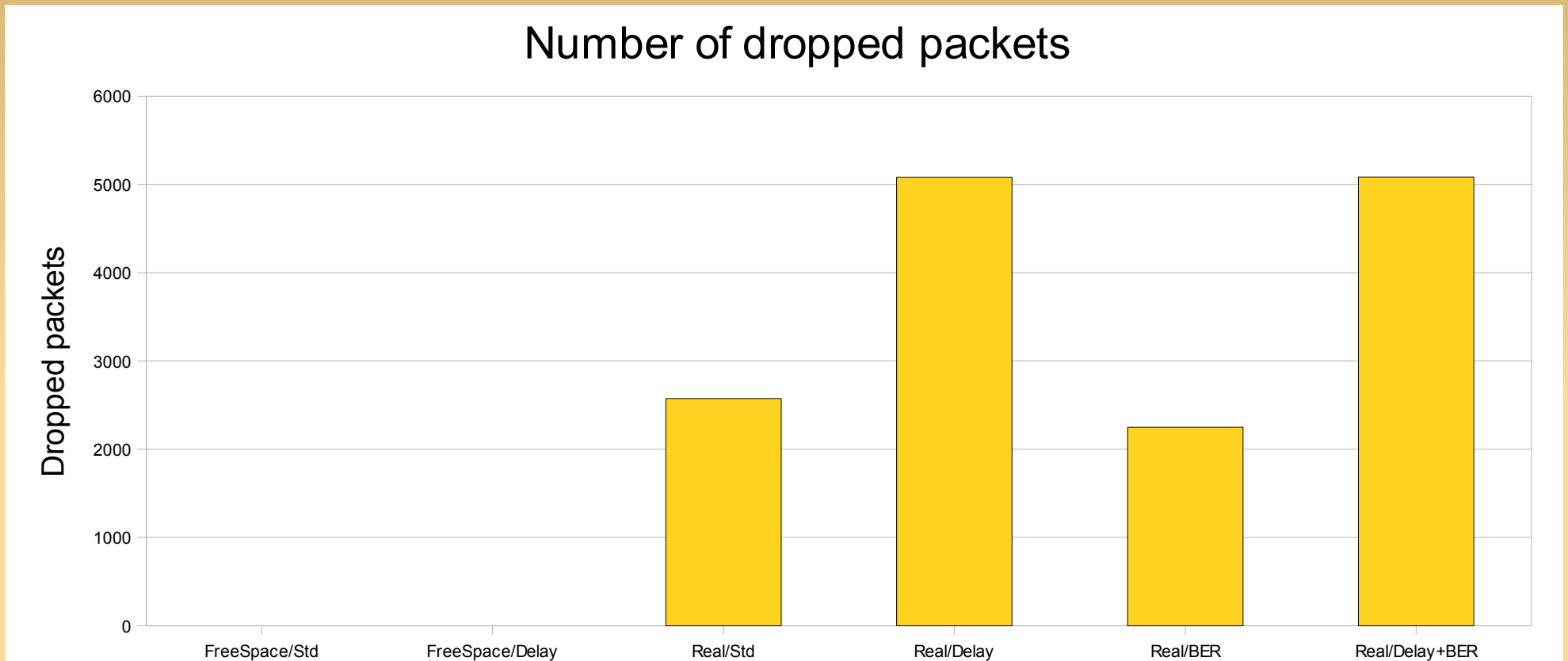
# 3. V-AODV Evaluation



*Average end-to-end delay depending on Propagation Model and Protocol*

- V-AODV (Delay) improves the AEED
- V-AODV (BER) decreases the AEED
- V-AODV (Delay+BER) improves the AEED

# 3. V-AODV Evaluation

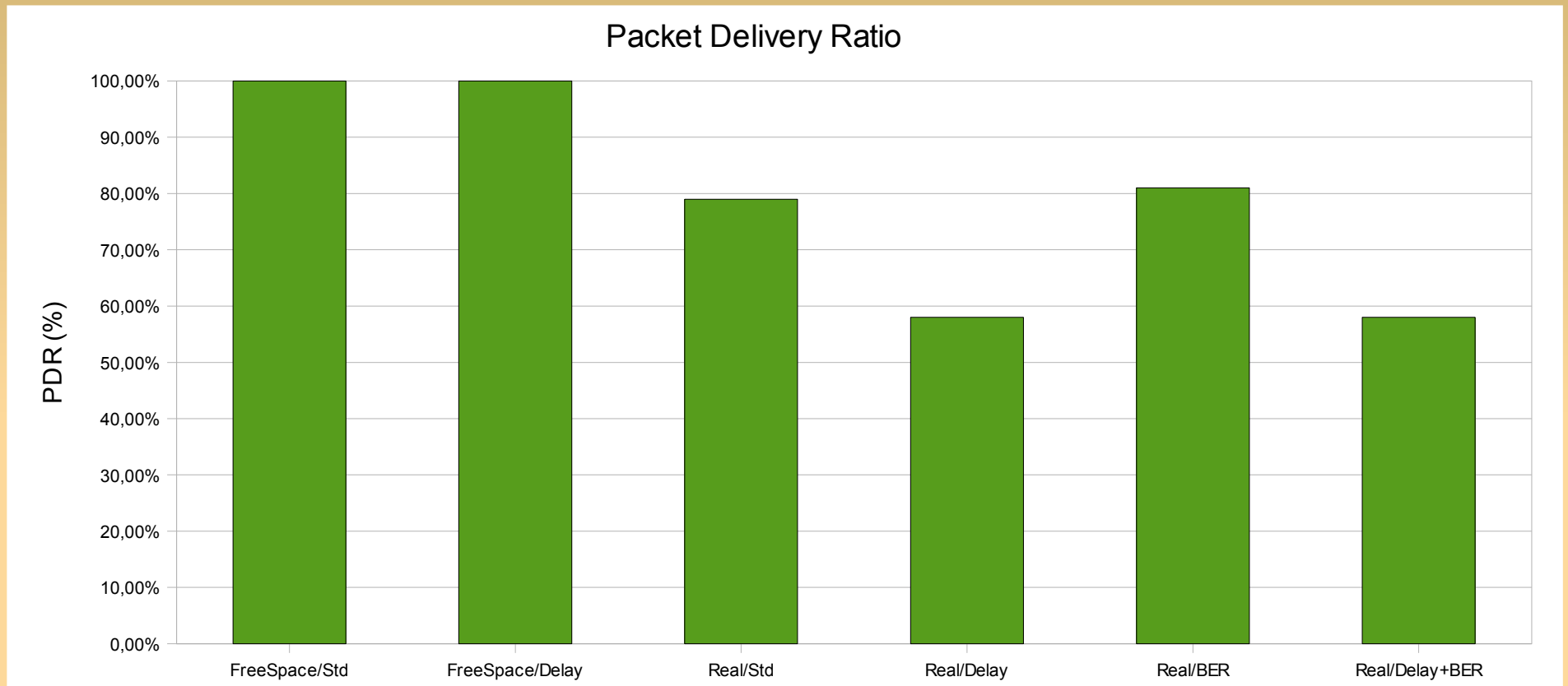


*Average number of dropped packets depending on Propagation Model and Protocol*

- V-AODV-Delay decreases the QoS for dropped packets
- V-AODV-BER improves the QoS for dropped packets
- V-AODV-Delay+BER decreases the QoS for dropped packets



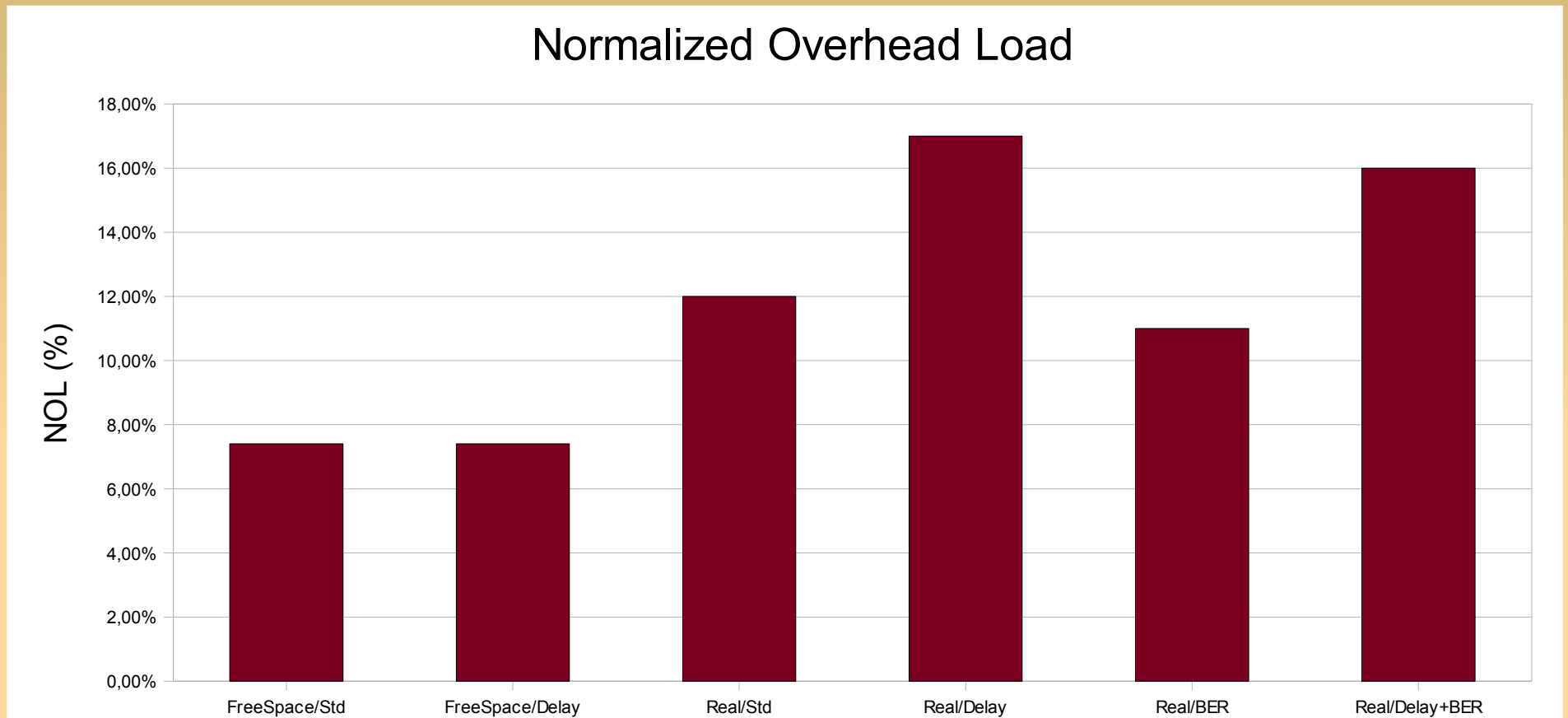
# 3. V-AODV Evaluation



*Average PDR depending on Propagation Model and Protocol*

- V-AODV-Delay decreases the PDR
- V-AODV-BER increases the PDR
- V-AODV-Delay+BER decreases the PDR

# 3. V-AODV Evaluation



*Average NOL depending on Propagation Model and Protocol*

- V-AODV-Delay and V-AODV-Delay+BER needs more packets to discover and to maintain routes
- V-AODV-BER needs less packets to discover and to maintain routes

# 4. Conclusions

## V-AODV-Delay Main Characteristics

Improves the AEED, but decreases the PDR.

## V-AODV-BER Main Characteristics

Improves the PDR, but decreases the AEED.

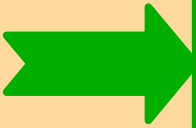
## V-AODV-Delay+BER Main Characteristics

V-AODV-Delay+BER has the same advantage and disadvantage than V-AODV-Delay.

# 4. Conclusions

## Main Conclusion:

It seems to be a nonsense to evaluate a protocol for VANETs with a simplistic propagation model like Free Space or Two Ray Ground.



In order to properly evaluate a new protocol for VANETs, a realistic radio propagation model has to be used.

# 4. Future Works

We now have a way to really evaluate any new wireless protocol, and the ability to compare it precisely with others.

Our future work will try to improve V-AODV by including new metrics and combining them.

We will also evaluate the protocol in different environments like highways or larger cities.

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