Experimental Study on the Impact of Vehicular Obstructions in VANETs

Rui Meireles, Mate Boban
Ozan Tonguz, Peter Steenkiste, Joao Barros
Outline

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• Goal
• Experimental setup
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• Conclusion
Motivation

- Simulations: major tool in VANET research
- V2V channel models generally do not model the vehicles as physical signal obstructions
- Vehicles in simulations: dimensionless entities
Motivation: Obstructed neighbors

- Empirical study analyzed line-of-sight (LOS) conditions \[1\]
- Half of the vehicles do not have LOS due to obstructing vehicles

Goal

• Experimentally evaluate the impact of on Tx & Rx
  ▪ Both controlled and real life environments
• Use results to calibrate V2V channel models
Experiment Scenarios

• **Parking lot:** controlled environment
  - Obstructions, distance, surroundings

• **On-the-road:** Highway, Suburban, Urban
  - Time of day
    - Day (frequent NLOS) / Night (infrequent NLOS)
    - Exact same routes
  - One hour experiment runs
Experiment Setup

WiFi (802.11b/g): 2.4 GHz
DSRC (802.11p): 5.9 GHz

<table>
<thead>
<tr>
<th>Parameter</th>
<th>802.11p</th>
<th>802.11b/g</th>
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</thead>
<tbody>
<tr>
<td>Channel</td>
<td>180</td>
<td>1</td>
</tr>
<tr>
<td>Center frequency (MHz)</td>
<td>5900</td>
<td>2412</td>
</tr>
<tr>
<td>Bandwidth (MHz)</td>
<td>20</td>
<td>20</td>
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<tr>
<td>Data rate (Mbps)</td>
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<td>1</td>
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<td>Antenna gain (dBi)</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>Beacon frequency (Hz)</td>
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<td>10</td>
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<tr>
<td>Beacon size (Byte)</td>
<td>36</td>
<td>64</td>
</tr>
</tbody>
</table>
Parking Lot

- Specified Tx – Rx distances (10, 50, 100 m..)
- Specific LOS conditions (LOS, van, truck..)
- Static environment
  - Empty lot
  - Same day
  - Same weather
Highway - U.S. I-79 between Pittsburgh, PA and Grove City, PA
Suburban - 5th avenue, Pittsburgh, PA
Urban – Downtown Pittsburgh
Results – Parking Lot: Van

- Average RSSI with and without the obstructing van
- 20+ dB attenuation at short distances
- Absolute difference between 2.4 and 5.9 GHz due to:
  - Radio quality, antenna gains, cable loss, etc..

\[
\text{RSSI} = \text{received power (in dBm)} + 95
\]
Results – Parking Lot: Truck
Results – On-the-road Experiments

- Daytime experiments: 40% NLOS due to vehicles
- Night time experiments: 5% NLOS due to vehicles
Results - RSSI

Overall results: highway + suburban + urban
(200k data points)

Difference
10m - 9dB
100m - 8dB
200m - 7dB
300m - 5dB
Results – Packet Delivery Ratio

Overall results: highway + suburban + urban
(200k data points)

Packet Delivery Ratio

Difference
200m - 18%
300m - 25%
400m - 28%
Results – Reliable communication range

- 60 percent decrease in range due to vehicles
- 85 percent due to static obstructions

![Diagram showing reliable communication range](distance_meters.png)

**Reliable communication range (max. distance at which the PDR was above 90%)**
Conclusions

• Obstructing vehicles significantly attenuate the signal across all experiment scenarios
  ▪ Effect is more pronounced at shorter distances
  ▪ Single vehicle can cause more than 20 dB drop
• Effective communication range halved for target PDR of 90%
• Results emphasize the need for link level channel modeling
Experiment visualizer

http://drive-in.cmuportugal.org/los
Thank you