Potential of Cooperative Systems for Automated Driving

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Car-2-X Communication

- Driver gets informed about an upcoming dangerous situation at an early stage
- Potentials are improved road safety, reduced traffic congestion and more environmentally friendly driving
IEEE 802.11p

- Modification of 802.11a
- In Europe called ITS-G5 (band, channel allocation)

<table>
<thead>
<tr>
<th></th>
<th>IEEE 802.11a</th>
<th>IEEE 802.11p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data Rate</td>
<td>6, 9, 12, 18, 24, 36, 48, 54 Mbps</td>
<td>3, 4.5, 6, 9, 12, 18, 24, 27 Mbps</td>
</tr>
<tr>
<td>Modulation</td>
<td>BPSK OFDM</td>
<td>same</td>
</tr>
<tr>
<td></td>
<td>QPSK OFDM</td>
<td></td>
</tr>
<tr>
<td></td>
<td>16-QAM OFDM</td>
<td></td>
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<tr>
<td></td>
<td>64-QAM OFDM</td>
<td></td>
</tr>
<tr>
<td>Error Correction Coding</td>
<td>Convolutional Coding with K=7</td>
<td>same</td>
</tr>
<tr>
<td>Coding Rate</td>
<td>1/2, 2/3, 3/4</td>
<td>same</td>
</tr>
<tr>
<td>OFDM Symbol Duration</td>
<td>4 μs</td>
<td>8 μs</td>
</tr>
<tr>
<td>Guard Period</td>
<td>0.8 μs</td>
<td>1.6 μs</td>
</tr>
<tr>
<td>Bandwidth</td>
<td>20 MHz</td>
<td>10 MHz</td>
</tr>
<tr>
<td>Frequency Range</td>
<td>5.180 GHz - 5.825 GHz</td>
<td>5.850 - 5.925 GHz</td>
</tr>
</tbody>
</table>
The Road to 5G

Source: http://www.lte-anbieter.info/5g/
Car-2-X Demonstrator System

Vehicle (ECU, Instrument Cluster) → Car-2-X platform - MKx (ITS application) → Tablet PC (Car-2-X App)

CAN → Bluetooth

GPS

ITS G5

CAUTION! Braking vehicle ahead

Car-2-X Demo Video
So far automated car demos have been sensor based

→ Unlock the potential of cooperative systems for automated driving
Why Car-2-X?
Car-2-X can play a key role in future automated driving
Deployment of Cooperative Automated Vehicles

1. Local Sensing
2. Map & Position
3. Communications Module
4. Sensor Fusion
5. ‘Connected’ Environmental Model
6. Vehicle Control
7. Brake
8. Steer
9. Cooperative Automated Vehicle

Phase 1
Phase 2
Phase 3
Phase 4
Phase 5
• Individual vehicle knows about its local status (speed, position,…) and environment (other vehicles, pedestrians,…)

• So far just transmission of own information (‘local status’)

• Adaption: Automated vehicle should also transmit **perceived information** about the environment
  – Pedestrians, biker, potholes,…

• This information is used to update its environmental model
  → ‘**connected environmental model**’
Ultra-rapid precise Positioning for crash Impact potential Calculation (UPIC)

**Today's** Collision Prediction Systems based on:
- Radar
- Camera

**UPIC** based on:
- C2X Communications
- Low-Cost GNSS
- Standard Vehicle Sensors
- Lane-level Digital Road Map (DRM)

→ Cooperative system for collision prediction

Source: ifG, TU Graz
Thanks for your attention!