Wireless connectivity in automotive

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My first car
My first car

Wireless optical transmitters

Some of the functions left to the user
- Detection → radar
- Decision → artificial intelligence
- Actuation → steer by wire

Stereo wireless optical receivers

Decision making (brain) and actuators (body)
Wireless in automotive

- Wireless technology has (always) been present in automotive
  - Safety: communications and sensing
  - Entertainment: communications

- The car is not an isolated player
  - Cooperative rather than autonomous
Contents

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• Wireless in automotive: an NXP view
  • Broadcast
  • V2x
  • Radar

• Vision and conclusions
Wireless in automotive: where NXP plays today

- NFC
- 802.11p
- Radar
- Portable Device Connectivity
- LF, UHF
- ISDB-T
- DAB
- HD Radio
- SiriusXM
- FM/AM
Wireless in automotive: where NXP plays today
Broadcast reception: innovation

- Mature technology, but still room for differentiating the end-user experience
  - Increased coverage

- Technical challenge
  - Achieve the target BER in tough conditions: SNR and multipath
Compression of Log Likelihood Ratio

Problem statement: support a distributed architecture with low cost and high performance

Distributed reception
- 70% compression at 0.2dB performance loss
- Distributed reception at low link bandwidth
- Separately quantizing channel and signal information
- Low in VDSP MIPS and no significant latency
Compression of Log Likelihood Ratio

DAB time deinterleaver memory reduction

- 20% deinterleaver memory reduction at no performance cost
- Use non-uniform quantization (saturation at reliable levels).
  - Max/min values and low magnitude LLRs should be disturbed less
  - 1 bit saving wrt conventional uniform quantization approaches.
  - Simple LUT based conversion
Broadcast reception: next innovation steps

• Interaction between Viterbi and Reed-Solomon decoder

• Iterative decoding with limited resources
  • Compress the I/Q sample?

• Interference management for in-band standards
Wireless in automotive: where NXP plays today
Cooperative Intelligent Transport System (C-ITS)

- Cooperative Intelligent Transport System (C-ITS)
- Communicating vehicles and infrastructure
- Vehicles can be cars, airplanes, trains and ships
- The Central traffic Management System (CMS) manages the C-ITS
V2X Roadmaps – Applications

Status Data
- Intersection Collision W
- Emergency Vehicle W
- Pre-/Post-Crash W
- ...

Sensor Data
- GLOSA 1.0
- In-Vehicle Information
- VRU Warning 1.0
- ...

Intention Data
- GLOSA 2.0
- Cooperative ACC
- VRU Warning 2.0
- Platooning
- ...

Coordination Data
- Cooperative Merging
- Overtaking Assistance
- VRU Assistance
- ...

Take-over of the driving function
- Fully Automated Driving
- Optimal Traffic Flow

Automation Level
- Phase 1: Awareness
- Phase 2: Sensing
- Phase 3: Cooperative
- Phase 4: Synchronized Cooperative
- Phase 5: Accident-free

Dissemination
Cooperation

100% installation of new vehicle sales
100% installation of new vehicle platforms
10 year ramp-up to 100% installation of new vehicles
Installation on select new vehicle type of luxury and upper class vehicles

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V2X communications

Extend sensing beyond own vehicle and beyond line of sight

802.11p required for Safety-critical V2X features

- Providing additional safety data earlier than any other sensor can „see“
- Low latency
- Secure
- Beyond-line-of-sight
- Ad-hoc network
- 7 channels of dedicated licensed spectrum
V2x communications: Innovation

• Mature technology, new market
  • We are very close to start deploying 802.11p for V2x
    • After 10 years of testing and investments, we are ready to save lives!
  • The cellular community is undergoing the ‘next-generation’ cycle
    • Everybody talks about the next generation: 5G
    • Lots of claims, lots of confusion, little facts
    • Ambition is to cover everything: automotive, low power IoT, ...

We do not want the claims of the cellular community to jeopardize the societal benefit of V2X
Why 802.11p beats LTE and 5G for V2x. Because ...

... 802.11p supports all Vehicle to Vehicle use cases with their unique application requirements: No network and low latency. Cellular technologies don’t.

802.11p

- Originally designed for these applications
- Licensed allocated resources
- Ready and validated: 10 years of fields trials
- US mandate is expected soon
- Unique functional safety and security requirements

Cellular technologies: LTE and/or 5G

- Never dealt with these application requirements before
- They do not support them
  - V2x study group in 3GPP
- Niche market with tough requirements
- The will surely be able to, but it will take time
# Future of V2X

## 802.11p and cellular

<table>
<thead>
<tr>
<th>Feature</th>
<th>802.11p</th>
<th>Cellular</th>
<th>802.11p + Cellular</th>
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<tbody>
<tr>
<td>Operation in absence of network</td>
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<td>Support of V2V</td>
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<td>Support of safety-critical use cases</td>
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<td>Support of multimedia services</td>
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<td>Support of V2I/I2V</td>
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<td>Network coverage</td>
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<td>Advanced PHY</td>
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Leverage on:

- the gaining momentum of DSRC/802.11p
- the increased interest of the cellular community for DSRC applications

...to build a sustainable future for V2X by combining the best of 802.11p and cellular (HetVEN)
V2x: next innovation steps

- Address known shortcomings of the technology
  - Distributed Congestion Control (w TUE)

- Next generation 11p standard (w TUE and NTU)
  - Match the efficiency of modern communications technologies: shaping gain/Cooperative communications
  - 11p and 5G

- Precise positioning (NTU)
Wireless in automotive: where NXP plays today
Automotive radar: safety and comfort

Once a slot has been found, the driver stops and puts the car in reverse thereby activating the automated steering.

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Radar Sensor system

- Multiple sensors per car, different field of view, sensor fusion
- Trade-offs in maximum range, resolution and antenna design
- Complementary technologies: Camera, LIDAR, ultra-sonic.
  - Robust (weather, light)
  - Direct distance and speed measurement
  - Invisible integration
Data in real life

Reference receiver chain

• Range
• Velocity: A/B measurements
• Angular: Multi antenna support, and super-resolution
• Clustering and ego-motion estimation

SRE project “Pre-automated driving”
Target list visualization: snapshot

- Split between moving and still standing detections
- Radar position updated according to estimated ego-motion and measurement time
- Road edges clearly visible
- Some errors in
  - DOA estimation
  - Velocity ambiguity
The next generation automotive Radar waveforms

- Today: FMCW is the de-facto standard radar waveform
- Tomorrow: ?

High resolution radar
Toward lidar-like performance

High density radar
Highly integrated, distributed

Increase resolution
- Space, velocity, range

Interference management
- Interference mitigation: MAC protocols (standardization)
- Synchronization over the air of multiple units
- Embed information in the radar waveform
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Wireless connectivity for Automotive

- Societal benefits: “Road to Zero”
  - Autonomous cooperative driving
    - Pro-actively share information among actors
      - Data: Sensor (radar) data, vehicle data
      - Technology: V2x, V2x + cellular
    - System view
  - Innovation in wireless technology
    - Combine radar and communications (iCAVE)
    - In-band full Duplex
Conclusions

- Wireless vehicle-to-vehicle communications is at the heart of automotive

- Key technical differentiators are extremely important for our business
  - Industry + Academia is a win-win construction
    - Academia: deep theoretical understanding
    - Industry: problem formulation (broadcast, V2x, Radar)

- There’s so much exciting work ahead of us!