SE24/SRD-MG: NXP introduction on ITS

December 9-13, 2013
FB 2.065
Agenda

- NXP announcements
- ITS being deployed
- Europe loves WiFi
- Coexistence
- Demo

Andrew Turley
NXP Director of Innovation & ITS Program Manager
NXP connects the Car

Car to Car, Car to Infrastructure, Car to Portable, Inside the Car
Cisco, NXP Invest in Cohda Wireless to Enable the Connected Car

Advancing Intelligent Transport Systems and Car-to-X Communication

Eindhoven, the Netherlands, January 4, 2013:
Cisco (NASDAQ: CSCO) and NXP Semiconductors N.V. (NASDAQ: NXPI) today announced that they have each made an investment in Cohda Wireless to advance intelligent transportation systems (ITS) and car-to-X communications.

- NXP will exclusively license the Cohda IEEE 802.11p technology together with its market proven SDR chipsets as a one-stop shop to automotive customers.
- Onboard and road side units developed using technologies from NXP, Cisco, and Cohda have been tested to global standards in major field trials such as the “Safety Pilot Model Deployment” trial by the US DOT, simTD in Germany, Score@F in France, and ERP2 in Singapore.
- NXP is member of Cohda’s board
NXP/Cohda unveil new V2X device for connected vehicles
MK4, the first RoadLINK™ product reference design for connected vehicles

Eindhoven, Netherlands, July 8, 2013:
Connected vehicle technology leader Cohda Wireless and NXP Semiconductors (NASDAQ: NXPI) announced the launch of the MK4, the latest generation of its connected car technology based on the RoadLINK chipset.

- Building on the success of the MK3, used widely in V2X trials globally, the MK4 will serve as the reference design for series-production of the 1st generation of connected vehicles, expected to launch in 2015. Compared with competitor solutions, the RoadLINK chipset exchanges messages reliably across an extended range and at high speed, cutting ‘time to react’ and communicating potential hazards and safety-critical scenarios significantly faster than conventional applications.

- Supporting both DSRC (IEEE 802.11p) and Wi-Fi (802.11abgn) wireless standards, the RoadLINK chipset can upload and access data via home wi-fi and hotspot connections.
NXP Delivers First RoadLINK Product for connected vehicles

First Car-to-X communications product, SAF5100, now sampling with major automotive OEMs and Tier 1 suppliers

Eindhoven, Netherlands and Tokyo, Japan, October 11, 2013:
NXP Semiconductors N.V. (NASDAQ: NXPI) announced that the SAF5100, the first product from the RoadLINK™ range, is now available for automotive customer design-in.

- The SAF5100 is a flexible software-defined radio processor for car-to-car (C2C) and car-to-infrastructure (C2I) communication, helping to realize NXP’s vision for a complete C2X (C2C+C2I) solution.

- Scheduled for mass production in the second half of 2014, the SAF5100 is also the first product to become generally available from the MK4 reference design for connected vehicles, following its unveiling in July by NXP and Cohda Wireless, a leading specialist in wireless communication for automotive safety applications.
Agenda

- NXP and ITS
- ITS being deployed
- Europe loves WiFi
- Coexistence
- Demo
Intelligent Transport Systems (ITS)

- Car-car and car-Infrastructure communication network
- Safety (dependable systems):
  - Beyond driver line-of-sight; hazardous location & Curve Speed Warning
  - Lane change warning
  - Collision Warning
  - Car as a Sensor
- Traffic/energy management & emissions reduction (support systems):  
  - Emergency vehicles
  - Speed congestion controls
  - Green light zone
- Supported by dedicated wireless standards  
  - ETSI/IEEE, Car2Car Communications Consortium
### ITS: Europe Day1 Use Cases

<table>
<thead>
<tr>
<th>Typical V2V</th>
<th>Typical V2I/I2V</th>
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<tbody>
<tr>
<td>Hazardous location warning</td>
<td>Probe Vehicle Data (Floating Car Data)</td>
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<tr>
<td>Slow vehicle warning</td>
<td>Signal phase and time of traffic lights</td>
</tr>
<tr>
<td>Stationary vehicle warning</td>
<td>Road works warning</td>
</tr>
<tr>
<td>Emergency brake light</td>
<td>In-vehicle signage</td>
</tr>
<tr>
<td>Emergency vehicle warning</td>
<td></td>
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<tr>
<td>Motorcycle approaching indication</td>
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</table>

- All V2V/C2C require 802.11p for range up to 2km
MK4a Evaluation Kit

- EU, US, JP (760 MHz) V2X Standards
- IEEE 802.11an Standards
- EU DSRC & JP DSRC Roadmap
- Board 8 cm x 10 cm
- Software Defined Radio, Cohda/NXP chip SAF5100
- TEF5100N1B Frontend
- Interfaces to NXP Security chips
- NEMA 2 and NEMA 4 enclosure available

Driver Interaction

Applications Layer
- Facilities Layer
- Network layer
- IEEE 1609 & SAE J2735
- ETSI TC-ITS

Vehicle State

Position & Time

Wireless Connectivity
- Dual 802.11 Radio
- Channel switching
- Dual Antenna

Ethernet, USB, HDMI, Audio

i.MX6 Processor

CAN

GNSS

802.11anp Radio

Front end
Value Proposition: V2V

**Do Not Pass Warning**
Reliable connectivity at extended range in safety-critical scenarios.

- **COTS**
- **Cohda**

**Time to Impact (Seconds)**

**Intersection Collision Warning & Movement Assist**
Extends connectivity to non-line-of-sight conditions – dramatically improving V2V applications.

- **COTS**
- **Cohda**

**Time to Impact (Seconds)**
Value Proposition: V2I

Curve Speed Warning, Security Updates
Dramatic increase in amount of data that can be uploaded or downloaded.

CICAS-V, RTK Corrections
Significant increase in connectivity range, improving effectiveness.
NXP/Cohda solution in Car-2-X trials

- Units delivered by Cohda based on RoadLINK
  - BMW, Opel, VW, Cohda Wireless

- Regions:
  - **Japan**: Targeted car2carfield trial
    - Potential Partners: Denso, Cohda Wireless
  - **Korea**: Targeted car2carfield trial
    - Potential Partners: Hyundai, Cohda Wireless
  - **Regional Field trial in Paris region**: to apply car2x technology
    - Partners: Renault, PSA, Cohda Wireless
  - **Trials for potential legislation in 2013**
    - Trials feed 2013 NHTSA Rule Making
      - Introduction 2015/2016 MY
        - Trials:
          - Module Deployment
          - Aftermarket Safety Devices
        - Partners:
          - Delphi
          - Visteon
          - Cohda
  - **Field trial and on-road demonstration of DSRC**
  - **Rail Trial**: 100 vehicle rail safety trial
    - Partners: University South Australia, La Trobe University, Cohda Wireless

- **SCORE@F**

- Units delivered by Cohda based on RoadLINK

- NXP/Cohda solution in Car-2-X trials
  - 13 units delivered by Cohda based on RoadLINK units delivered by Cohda based on RoadLINK
  - Cohda based on RoadLINK
  - Delphi
  - Visteon
  - Cohda
SimTD results (1)

- 500 participants joined
  - 41000 hours of testing
  - 1650000 KMs of driving
  - 30 Terabyte of data

- Highest-rated functions:
  - traffic jam end warning
  - Signal phase and time of traffic light
  - Emergency Brake light
  - ....

Question: what function would you like to have in your car?
SimTD results (2)

SIMTD calculated that in 2015:
- 6 billion Euros can be saved with ITS
  - Hazardous location warning
  - Emergency Brake Light
  - Signal phase and time of traffic lights
  - Others

& the cost of traffic jams comes on top

→ And this is in Germany only.

Ref: Simtd_factsheets_2013_de_web.pdf (www.simtd.de)
General Summary

1. 10 different devices tested, OBUs and RSUs
2. All tested at 5.900 GHz (IEEE channel # 180) @ 10 MHz
3. All tested with single antenna connector
4. Automation of Receiver tests worked for great majority of devices
   1. i.e. Readout of DUT MAC block counter via Ethernet
   2. Simple DUT to test PC interface worked fine
5. All modem test teams were well prepared!
   Thank you!
Out of band emission EN 302 571

100% of DUTs do NOT meet limits of critical ranges at maximum output power!
Note: No DUT did transmit more than 24 dBm. 33 dBm would be allowed!

Inband emission spectral mask

- To be measured at maximum output power
- Max output power measured in the range of 0 to 20 dBm
- 40% Failed EN 302 571 spectrum emission mask
- 60% Passed EN 302 571 spectrum emission mask

Spectral MASK C is met
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What is happening?

- In October 1999, FCC allocated 75 MHz of spectrum in the 5.9 GHz band (5.85 GHz and 5.925 GHz) for Dedicated Short Range Communications (“DSRC”)
- FCC requested comments on a potential sharing of the DSRC band, to understand if a feasible sharing solution that protects DSRC users could be developed
  - DSRC would remain as a primary user
  - Part 15 IEEE 802.11-13 General Conditions: “no harmful interference”
  - IEEE 802.11 Regulatory SC DSRC Coexistence Tiger Team
  - FCC rule-making will be concluded in next 6 months (now phase 4)

- In August 2008, EC Decision 2008/671/EC harmonised use of radio spectrum in the 5875-5905 MHz frequency band for safety-related applications of ITS
- European Commission mandated to CEPT to study and identify sharing conditions … ensuring safety-related operation in line with the provisions of Decision 2008/671/EC ➔ SE24
  - Aug 2013: Publication of “Europe loves Wi-Fi” document which seeks “…to make spectrum from 5150 MHz to 5925 MHz available globally for Wi Fi”
  - Start 2014: EU Road Authorities start V2I introduction in cities & highways
  - Start 2015: Semiconductor manufacturers release Automotive grade products for MY2016
  - Start 2016: SoP for ITS-equipped vehicles in EU by leading Car OEMs
  - July 2016: WRC 2015 to decide on allocation of 5150-5925 MHz to the mobile service on a primary basis
John Kenney, principal research manager at the Toyota Info Technology Center CA

- ... should not move forward with a plan to allow expanded parts of the wireless spectrum for Internet access until viable technology-sharing is demonstrated

- ... We don’t want a mom driving a car down the road with kids in the back seat, and because she happens to be driving by a coffee shop that’s using Wi-Fi, her collision-avoidance system turns off

- .. regulations must ensure that kids using devices in the back seat don’t interfere with the safety system

The Alliance of Automobile Manufacturers and Association of Global Automakers urged the FCC earlier this year not to allow unlicensed wireless devices to operate in the 5.9-GHz frequency band that has been designated for exclusive use for vehicle-to-vehicle and vehicle-to-infrastructure communications.
A significant investment has already been made in ITS technology & infrastructure:

- John Kenney:
  - Since 2005, automakers and governments have spent about $130 million researching and testing the technology
  - Nearly 3,000 cars, trucks and transit buses are testing connected-vehicle technologies on 73 miles of roads in northeast Ann Arbor
  - In August, the one-year test was extended by another 6 months
  - Vehicle-to-vehicle technologies have the potential to significantly reduce crash fatalities and injuries, and could one day help motorists avoid crashes altogether
  - NHTSA estimates the technology could one day help prevent up to 80 percent of traffic crashes
Consumer WiFi market is large and fast-moving, compared to Automotive:

- WiFi needs more bands as the traffic it sustains is growing and growing
  - 11ac will be successor to 11n long-term … sure to leak outside and interfere

- John Kenney:

- Cisco’s VP & CTO, Bob Friday:
  - Cisco predicts nearly two-thirds of U.S. Internet traffic will be Wi-Fi based by 2017. Six billion Wi-Fi enabled devices have been shipped since 2000; it’s expected to grow to 15 billion by 2017.

- The EU automakers initially will use a small section of the spectrum from 2015
At the Car2Car Forum in Munich three independent groups presented their concerns about 802.11ac sharing:

- Ford US / CAMP/VIIC
- Regulation consultants (CEPT-SE24)
- Semiconductor Alliance
  - Autotalks, Renesas, NXP, Cohda
Why DSRC spectrum is important to Wi-Fi?

- Wide bandwidth channels desired to support high throughput requirements (802.11ac targeted at 1.7Gbps data rate per user)
  - Higher bandwidth channels (80MHz, 160MHz) are very valuable assets for 802.11ac

- Additional unlicensed use of 5.35-5.47 GHz and 5.85-5.925 GHz would allow
  - Three additional 80 MHz channels (six → nine)
  - Two additional 160 MHz channels (two → four)
Why is WiFi spectrum important to DSRC?

IEEE channel #

<table>
<thead>
<tr>
<th>Channel</th>
<th>Service</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>CH 172</td>
<td>V2V CRASH</td>
<td>V2V AUTONOMOUS VEHICLES &amp; PRE-CRASH</td>
</tr>
<tr>
<td>CH 174</td>
<td>V2V Service</td>
<td>V2V AUTONOMOUS VEHICLES &amp; PRE-CRASH</td>
</tr>
<tr>
<td>CH 176</td>
<td>NOTIFY, SECURITY, BROADCASTS</td>
<td>V2I Cooperative Vehicle-Highway Automation System</td>
</tr>
<tr>
<td>CH 178</td>
<td>V2I SECURITY CERTIFICATES</td>
<td>V2I Cooperative Vehicle-Highway Automation System</td>
</tr>
<tr>
<td>CH 180</td>
<td>V2I Service</td>
<td>V2I Cooperative Vehicle-Highway Automation System</td>
</tr>
<tr>
<td>CH 182</td>
<td>V2I PUBLIC SERVICE</td>
<td>V2I Cooperative Vehicle-Highway Automation System</td>
</tr>
<tr>
<td>CH 184</td>
<td>Non Safety</td>
<td>Safety Low Latency</td>
</tr>
</tbody>
</table>

EU tolling and special services

USA

Europe
SE24 early analyses Conclusion

- Depending on the scenario, the studies showed required, minimum separation distances from **295m** up to **1810m** between 5GHz RLAN devices and ITS systems.

- The spectrum sharing with 5GHz RLAN-devices is only possible if the 5GHz RLAN output power does not exceed:
  - **-38 dBm/MHz** e.i.r.p. indoor
  - **-57 dBm/MHz** e.i.r.p. outside
  - **-63 dBm/MHz** e.i.r.p. within a vehicle

Ref: Spectrum sharing in 5850-5925 MHz and 5795-5815 MHz, Car-2-car Forum 2013 Day1:
Dr. Friedbert Berens and Paul Spaanderman
Test description

Harmful Interference to 5.9 GHz DSRC Connected Vehicle Safety – DSRC Packet Loss

SAMPLE LOS LINK RANGE TEST WITH IN-VEHICLE WIFI INTERFERENCE
(V2V test shows high-CCA-threshold issue for overlapping WiFi packets)

- DSRC LINK ON CH174 (10MHZ CHANNEL)
- WIFI TRANSMITTER ON CH 175 (20MHZ CHANNEL, CH174 + CH176)
- EXAMPLE CAR-TO-CAR OUTBOUND DRIVE TEST

Diagram of WiFi Interference Experiment:
LOS outbound test performed with & without WiFi Interference
With no WiFi interference → LOW PER

Reference plot:
- DSRC car-to-car link range on city street
- No in-vehicle WiFi interference
- Green shading shows low PER over link range
WiFi interference $\rightarrow$ HIGH PER, limited range

WiFi power: 12 dBm

- WiFi interference at 12dBm, 38% channel loading
- Red shading shows high PER over range >45m

DSRC car-to-car link range with WiFi interference (20MHz),

- WiFi interference at 12dBm, 38% channel loading
- Red shading shows high PER over range >45m
WiFi interference → HIGH PER, limited range

WiFi power: 18 dBm

DSRC car-to-car link range with WiFi interference (20MHz),
- WiFi interference at 18dBm, 38% channel loading
- Red shading shows high PER over most of the link range
Concluding Remarks

- Since 2005, US Carmakers and Governments have spent >$130M researching and testing the 5.9GHz DSRC ITS standard and technology
- 5.9GHz DSRC is required for EU & US V2V, and some V2I safety-critical applications, and must be protected from harmful interference
- Studies in US and EU have shown that DSRC & 11ac spectrum sharing cause harmful interference to DSRC
- A global solution is strongly preferred because mobile & consumer 11ac products are ubiquitous (indoors, outdoors, in-vehicle) ➔ Cooperation is needed between IEEE 802.11 DSRC Tiger Team & SE24
- Certain changes to the 5.9GHz DSRC standard could delay introduction of ITS technology by more than 5 years, pushing out EU introduction beyond 2020
- In Germany alone, more than $6B can be saved by introducing ITS systems
- Spectrum issues are now on the agenda of DG-MOVE, after the high-level ITS Advisory Group meeting with the EU Commission ➔ Platform team to be setup
Thank you!