The “Telematics Horizon”
V2V and V2I Networking

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**Telematics horizon**: the reach of sensor awareness of a “connected car” compared to *line of sight* for an unconnected one.

*Origin*: Daimler, per Dr. Christian Weiß
Goal: increase safety and reduce accidents

First semi-autonomous vehicles (H/T Greg Dibb, Nissan)
Agenda

- Introducing vehicle-to-infrastructure (V2I) and vehicle-to-vehicle (V2V)
- V2X hardware and protocol stacks
- Safety Pilot and simTD pilots
- Security and GeoNetworking (Q&A)
- Future prospects
“Killer App”: Signal Phasing and Timing (SPaT)

SpaT will allow drivers to set optimal green-signal speed.
What hardware will automotive internets use?

802.11p
802.11p vs. LTE vs. Satellite and FM

- 802.11p is the only low-latency safety channel.
- LTE has the largest install base and is industry-funded.
- Terrestrial and satellite radio will carry vehicular data:
  - 3G (UMTS) already employed in simTD.
  - Telcos are investing heavily in automotive.
Why V2V needs low latency

Target Scenarios for Forward Crash Warning (FCW) & Lane Change Warning (LCW)

**FCW**
- Lead Vehicle Stopped
- Lead Vehicle Slower
- Lead Vehicle Decelerating

**LCW**
- Changing Lanes/Same Direction
- Drifting/Same Direction
- Turning/Same Direction

Source: J. Harding, Connected Vehicle Public Meeting
802.11p (WAVE) vs. other Comms Modes

- Lower-overhead protocol for safety messages.
- No access point (AP) and no basic service set (BSS)
  - Add too much delay for moving vehicles.
  - Lower latency than 802.11a/b/g/n, LTE or satellite.
- Message priorities 0-7.
- Half-width channels; always ad hoc.
- Up to 33 dBm (~1 km) in E.U. and 44 dBm in U.S.
- No upstream Linux kernel driver.
Manufacturers of 802.11p radios

- NEC
- Cisco/Cohda Wireless
- Commsignia (BSD-based)
- Denso
- Delphi
- Savari
- Kapsch
- Siemens
- UNEX
- AutoTalks
- Arada
- DGE
- Componentality

UNEX DCMA-86P2 miniPCI

collected by Alexandru Petrescu, cea.fr
Products are all OpenWRT-based routers?

802.11p chipsets made by Atheros, Ralink, Cohda/NXP

Image: “IntelliDrive Technology based Yellow Onset ® Decision Assistance System for Trucks”, Sharma et al.
Componentality: open-source 802.11p stack: the **bluez** of DSRC?

Typical Set Of Technologies

- OpenWrt
- ATHxK drivers
- WAVE library
- ITS applications

...and nothing else!

OpenWRT: actively developed Linux variant designed for wireless routers, works on MIPS, ARM, x86.

Source: “Using Open Source Solutions for V2V and V2I Communications,” Automotive Grade Linux webinar
Linux in V2I:
Advanced Transportation Controller (ATC)

Applications: SPaT; Traffic Surveillance; Ramp Meter; Dynamic Message Signs; Weather monitor; Weigh stations; Rail intersections; Lane usage controls; Roadworks warning . . .

Source: Institute for Traffic Engineers
Recently completed field trials:
Safety Pilot and simTD
U.S. DSRC: safety protocol

Two stacks: safety stack does not use TCP/UDP or IP

Fig. 2. Layered architecture for DSRC communication in the US.

CEN DSRC in Europe = electronic tolling
(Comité Européen de Normalisation)

TRX-1320
Single-Lane Transceiver.

The single-lane transceiver TRX-1320 is part of the TS3200-06 road-side system. The transceiver is intended for use in applications based on 5.8 GHz Dedicated Short Range Communication (DSRC) according to the European Committee for Standardization (CEN) TC278 DSRC and electronic fee collection (EFC) standards.
Safety Pilot trial in Ann Arbor MI

- Originally 8/2012-8/2013, but extended.
- 2800 cars, trucks and buses from 7 automakers.
- 64 embedded systems, 300 aftermarket and rest transmit-only.
- National Highway Transportation Safety Administration decision late 2013.
  - “Notice of Proposed Rule Making” likely late 2014
- V2V only so far; V2I planned.

U.S. extends connected vehicle pilot program in Ann Arbor

The National Highway Traffic Safety Administration is extending a pilot project in Ann Arbor on connected vehicles by another six months, but said it won’t change its timetable for deciding whether to move forward with the new technology.
E.U.'s Safe Intelligent Mobility—Test Area Germany (simTD) Pilot

- Opel; Audi; BMW; Daimler; Ford; VW; Bosch; Conti; Deutsche Telekom, plus govs and unis.
- 120 vehicles and 3 motorcycles plus RSUs.
- Data collection 2012-6/2013, 41K hrs and 1.65M km.
- 2015: ‘Cooperative ITS Corridor Rotterdam - Frankfurt am Main - Vienna’
  - Features “Roadworks Warning” and “Detection of Traffic Conditions”.
Dual protocol stacks of simTD

- Based on **ETSI ITS G5** plus GeoNetworking.

From *Automotive Internetworking*, courtesy M. Bechler, BMW.
Internet Engineering Task Force (IETF) work on Geonetworking and ITS

- 3 draft standards in preparation
  - Geonetworking (submitted)
  - 'Scenarios and Requirements for IP in Intelligent Transportation Systems' (submitted)
  - IPv6 over 802.11p (particular GENIVI interest)
  - V2X (with MANET working group of IETF?)

- Info: https://www.ietf.org/mailman/listinfo/its

- chief organizer: Alex Petrescu of CEA

- in contact with GENIVI Networking Expert Group
simTD's “vehicle stations”

Linux router + Windows XP Host

Resources

- simTD and Safety Pilot
- ITSSv6, CALM, ETSI, ISO C-ITS
- SAE, IEEE, ISO, IETF, FCC, NHTSA standards
- IETF-ITS mailing list
- Componentality's FlexRoad
- Automotive Grade Linux
- Telematics News, Wired Autopia
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- Andreas Festag, TU Dresden
- Special thanks to Sarah Newman and Kevin Dankwardt
Conclusions

- **Safety Pilot** and **simTD** trials indicate government and OEM commitment.
- 1st EU trial centers on V2I; US one V2V.
- EU vs. U.S.: compatible spectrum, but slightly different protocols.
- **IETF-ITS** and **Componentality** seek participants.
- HW is appearing, but remains expensive and lacks Linux implementations.
- Anticipated US decision will raise awareness.
Extra slides follow
Special cases

- Transit-service vehicles
- Emergency responders
- Over-the-air software updates
- Agricultural equipment
- Fleet vehicles
- Rental cars

... and many more.
Warning: not about streaming media or web browsers

Perlman’s View of ISO Layers

- 1: Physical
- 2: Data link: (neighbor to neighbor)
- 3: Network: create path, forward data (e.g., IP)
- 4: Transport: end-to-end (e.g., TCP, UDP)
- 5 and above: .... boring
Or proprietary IEEE-1609 stacks akin to Bluetooth?

BlueZ
Official Linux Bluetooth protocol stack

VS.
# V2V Model Deployment Safety Applications

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EEBL: Emergency Electronic Brake Lights  
FCW: Forward Collision Warning  
BSW/LCW: Blind Spot Warning/Lane Change Warning  
DNPW: Do Not Pass Warning  
IMA: Intersection Movement Assist  
LTA: Left Turn Assist

Source: M. Lukuc, Connected Vehicle Public Meeting
Safety Pilot's transit vehicle system

Source: S. Mortensen, Connected Vehicle Public Meeting
Glossary

- Common to EU and US:
  - Vehicle-to-vehicle (V2V)
  - Vehicle-to-infrastructure (V2I)
  - Wireless Access Vehicular Environment = IEEE-802.11p
  - WAVE Short Message Protocol (WSMP)

- Different:
  - On Board Unit (US) = ITS Vehicle Station (EU) = OBE
  - Road Side Unit (US) = ITS Roadside Station (EU) = RSE
  - Basic Safety Message (US) = Cooperative Awareness Message (EU)
  - Dedicated Short Range Communication (DSRC)
Participating standards bodies

- International: ISO, SAE, IEEE, IETF, ITU, ITE
- Europe: ETSI, CEN, C2C Consortium, Ofcom
- U.S.: FHWA, NHTSA, FCC, ASTM, V2C3
- Japan: ARIB
- Indian and Chinese activity
- ~5.9 GHz dedicated spectrum in both U.S and EU
- Analog TV “whitespace” in Britain (via BT) and dedicated spectrum in Japan
IETF ITS Standards History (courtesy A. Petrescu)

- Mobile Ad Hoc Network and NEMO: MANEMO BoF (2007)
- In-Vehicle Routing Requirements in Low Power and Lossy Networks (I-D 2008)
- Automotive Industry Requirements for NEMO Route Optimization (I-D 2009)
- Transport Protocol for Decentralized Probe Applications for Vehicles (I-D 2010)
- Best Current Practice for IP-based In-Vehicle Emergency Calls (I-D 2010)
- Traffic safety applications requirements (I-D 2010)
- ITSsv6, geocasting, DLEP protocol – informal meeting (2012)
- Potential topics of work: IPv6-straight-over-80211p, direct V2V and Geonetworking – bar BoF ITS (2013)
Feuer Labs' Exosense

What is it?

- Hardware and com libraries for connected devices
- OSS - MPLv2
- Interfaces low-level Linux APIs
- Written in Erlang
- Yocto build system fully supported
Internet Engineering Task Force
Internet-Draft
Intended status: Informational
Expires: March 23, 2014

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Internet-wide Geo-networking Problem Statement
draft-karagiannis-problem-statement-geonetworking-00

Abstract

This document describes the need of specifying Internet-wide location-aware forwarding IETF-based protocol solutions that provide packet routing using geographical positions for packet transport.
Safety Pilot participants

Roadside:
    Arada, Kapsch, ITRI, Cohda/Cisco, Savari

In-vehicle:
    AutoTalks, Cohda, Denso, DGE, ITRI, Savari, Arada

Aftermarket Safety Devices:
    Cohda/Delphi, Cohda/Visteon, Denso, Kapsch

Automakers:
    GM, Ford, Toyota, Honda, VW, Daimler, Hyundai and Nissan
Assured anonymity in a multicore, shared-radio architecture

With proper security, the radio can potentially be shared between the guests.

Linux guest on SOC core

Anonymous guest = Soft baseband on SOC core

RTOS with MAC, signing keys, no identifying info

Hypervisor with ARM Trusted Execution Environment

Prevents unauthorized identifying information from being transmitted

Thanks to Mentor's Faheem Sheikh and Felix Baum.
Ofer Shezaf, “Who can hack a[EV] plug?”

Potential Vulnerabilities

- Physical access
- Short range communications
- Encryption
- Internet of things
- The human factor

All the information in this section is based on public sources and in most cases from vendors’ web sites. Looking into the suggested possibilities is left as an exercise to the audience.
Architecture of simTD

Unlike SafetyPilot, includes Central Station and emphasizes V2I.
Ofer Shezaf, “Who can hack a[n EV] plug?”

Internet of things: protocols

Charge station to central management
• Identification, starting and stopping a charge transaction
• Reservations
• Maintenance: Setup, heartbeat, Configuration, Firmware Updates, Errors and diagnostics

Car to charge station
• Negotiate current
• Identification

Potential vulnerabilities
• Security by obscurity
• Trust in end points
• SSH and SNMP used extensively for management