Car Connectivity Coming Soon: When does it happen and what happens to transportation?

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1. DSRC: Past and Present
2. Other Wireless Technologies: LTE-Direct
3. Other Wireless Technology: 5G
4. Summary

Agenda
Feb 3rd, 2014: USDOT announced decision to move towards Dedicated Short Range Communication (DSRC) rulemaking
DSRC for Vehicular Communications

- Dedicated Short Range Communications (DSRC)
- 80% of road accidents can be addressed by this technology
- 75 MHz of bandwidth allocated in the 5.9 GHz band allocated by FCC in 1999
  - 7 channels of 10 MHz, 5 MHz reserved
- IEEE 802.11p for PHY/MAC operations
  - Half clocked 802.11a
- A joint effort between government, industry and academics over a decade
DSRC is Designed for the 5.9 GHz ITS Band

US Case

- Licensed under FCC Part 90 and 95
- Uses “communication outside the context of a BSS” defined in 802.11p
- No coexistence mechanism with commercial 802.11 (≥ 20 MHz channels)
- FCC designates certain channels, e.g. V2V safety, control, public safety
DSRC: **V2V** Standardization and Rulemaking are Major Forces

**Europe:** European Norm (EN) 453 mandates standardization of ITS G5

- First release 2013
- Issues in ‘mitigation’ / interference with 5.8 GHz tolling

**North America:** Impending NHTSA Notice of Proposed Rulemaking (NPRM): FMVSS Rule 150

- NPRM in 2016, potential mandate 1 – 2 years afterward, widescale deployment

- Institute of Electrical and Electronic Engineering (IEEE) and Society of Automotive Engineers (SAE) issued letters to expedite and complete by end of 2015
  - IEEE 1609.2 (security), 1609.3 (networking)
  - SAE J2735 (message sets), 2945.1 (minimum performance, including congestion control)

**Some convergence:** ETSI ITS TC WG1 and SAE DSRC TC (Platooning, V2P)

**What may influence timeline:**

- (Probable) Apparent cohesiveness among OEMs (e.g., Auto Alliance) vs. other interests (e.g., TIA)
- (Probable) Spectrum sharing battles (unlicensed WiFi sharing vs. ‘harmful interference Ch 178 – Ch 184)
- Resolution of Qualcomm’s FCC 5.9 GHz NPRM comments TBD
- Recent 3GPP (LTE standardization)/telecomm interest in V2V, V2X (for R13 (?), R14) → LTE-D
Enhanced Vehicle Services

Safety Case

- **V2V**: These were tested at the Ann Arbor Safety Pilot
  - Emergency Electronic Brake Lights (EEBL)
  - Brake “on” from several cars ahead sent to subject vehicle
  - Forward Collision Warning (FCW)
  - Alert to elicit hard braking to prevent rear-end crash
  - Blind Spot Warning/Lane Change Warning (BSW/LCW)
  - Alerts of fast-approaching cars from behind (and in adjoining lanes)
  - Do Not Pass Warning (DNPW)
  - Alerts for head-on crashes during passing maneuver
  - Intersection Movement Assist (IMA)
  - Left Turn Assist (LTA)

- **Issues?**: Yes: (1) Privacy-preserving, yet mandatory PKI, and (2) Congestion control

- **V2I**: “When you have a hammer, the whole world looks like a nail…”
  - Advanced traveler (and commercial) information systems (local dynamic data)
  - Dynamic arterial and freeway operations → system optimization
V2I is a Difficult Difficult

The Infrastructure Proposition Hinges on **Bolded** Items

**USA**
- NHTSA Decision February 2014
- Rapid V2V, Gradual V2I: U.S. start 2016, Mandate
- AASHTO Deployment Footprint Study, FHWA Guidance
- V2I Deployment Coalition

**Europe**
- 1st ETSI Release 1Q 2014
- Amsterdam Group-led Cooperative ITS Corridor(s) and COMPASS4D
- Gradual V2V &V2I: EU start 2015, No mandate

*US Connected Vehicle Deployments explicitly consider multiple OTA communications

California illustrates the problem: 1 State DOT + 58 counties + 482 municipalities
V2I as a whole is a tougher sell – but some deployment is believable

- **Communications equipment** (for DSRC or other wireless services) + enclosures, mountings, power, and network backhaul – WLAN or WWAN

- **Traffic signal controller interfaces** for applications that require signal phase and timing (SPaT) data

- **Mapping services** that provide highly detailed roadway geometries, signage, and asset locations.

- **Positioning services** for resolving vehicle locations to high reliability, accuracy and precision

- **Systems for management of security credentials.** *This is needed for V2V.*

- **Data servers** for collecting and processing data provided by vehicles and for distributing information, advisories, and alerts to users. *This is enabled by IVI/telematics (LTE-WAN).*

- Believable other comm media: 20% of IOT traffic may be V2X (Adreas Mai, Cisco, 30 March 2015)

What constitutes a connected vehicle infrastructure deployment?

Items in red are needed for V2V and/or

Some automated Vehicle deployment models
V2I Vision for 2040

- Up to 80% (250,000) of traffic signal locations will be vehicle-to-infrastructure (V2I)-enabled.
- 25,000 other roadside locations will be V2I-enabled.
- Accurate real-time localized traveler information will be available on 90% or more of roadways.
- Next-generation multimodal information-driven active traffic management will be deployed system-wide.

Embedded cellular in many new vehicles

1st DSRC in light vehicles (MY2020)

1st DSRC on 20% of signals

DSRC on 80% of signals

DSRC in 90%+ of light vehicles

Embedded cellular in most vehicles

AASHTO Footprint Analysis

FHWA Deploy. Guide

NHTSA Light V2V Decision

NHTSA Heavy V2V Decision

FCC Spectrum Decision

National Deploy. Plan

Vehicles

Infrastructure

Policy and Regulation

AASHTO: Infrastructure Deployment Timelines
Key Aspects for Standardization

- A thorough standard for vulnerable users may touch all layers of the standards
- Spectrum and PHY layer issues
  - Regulations for allowing smartphones as mobile safety devices
- Formal study of requirements for V2P use-cases
  - Understand the latency, range and signaling requirements for common use cases
  - Messaging/ Data dictionaries for new use cases
- Standards for improving positioning through ranging
- Security considerations for smartphones
- Congestion control
  - Number of pedestrians is much larger; need effective control to not impact vehicular safety
Other Wireless Technologies

Unlicensed

- Wi-Fi
  - 802.11b/g
  - 2.4GHz
- Wi-Fi
  - 802.11a/ac
  - 5GHz
- Wi-Fi
  - 802.11ad
  - 60GHz
- Bluetooth
- 802.11mc
  - Ranging

Licensed

- 2G/GSM
- 4G/LTE
- LTE Direct
- LTE Unlicensed
- 3G/CDMA
- 5G
- mmWave
- 802.11mc
  - Ranging
LTE Direct: Discover Everything Around You

Discover 1000s of devices in a 1000 meter vicinity
LTE Direct Discovery Attributes

**Continuous Discovery**
- Discovery at scale:
  - “Broadcast” based design
  - Efficient transmission
  - Range of up to few hundred meters

**Power Efficiency**
- Enables autonomous, “always on” discovery:
  - Detection and filtering at access (PHY) layer
  - Synchronous operation

**Designed for Density**
- Resource allocation based on density:
  - Distributed interference mgmt
  - Spectral efficiency and reuse

**Privacy Sensitive**
- Increased App adoption:
  - No location tracking by cloud
  - Potential app controls over cloud sharing
5G is about enabling new services and devices, connecting new industries, and empowering new user experiences
A Unified 5G Design That Is Scalable And Adaptable Across Extreme Variation Of Use Cases

- Support all 4G can do with improved network architecture and cost efficiency
- Enable new services and incorporate device-to-device communications, integrated access & backhaul
- Unified design for licensed and unlicensed spectrum
- Addition of new bands at higher frequencies including mmWave
- Advent of 5G will be concurrent with continued evolution of 4G
5G Radio Access Technologies

Low Latency & High Reliability Communication

Mobility-on-Demand

Vehicle-to-Vehicle

Multiple Access for More Active Connections

Full Self-Configuration

Even Denser Network Deployment with Interference Coordination

Massive Spatial Processing

Coordinated Spatial Techniques

Licensed & Unlicensed Spectrum in Sub-6 GHz and Above 6 GHz Including mmWave Bands

Integrated Access & Backhaul

Picocell Mesh

Multi-Hop Device-to-Device

Ultra Aware Network & Devices
Key Points

• DSRC: Standards-based V2V rulemaking opens the door for V2x
  – Provide population for V2I
  – ...otherwise, V2I will be slow to evolve

• Telecommunications are evolving
  – Many connectivity options to realize applications
  – Requirements in both reliability and throughput

• It is critical to ride on wave of wireless technology advances
Thank you

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