Dedicated Short Range Communication: What, Why and How?

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(http://www.d.umn.edu/ee/cvrl/index.html)

The Connected Vehicles Research Lab (CVRL) is located in the electrical engineering (EE) department of the University of Minnesota Duluth (UMD). The CVRL is involved in the state of the art research to improve driver safety and traffic mobility using vehicle to vehicle (V2V) or vehicle to infrastructure (V2I) wireless communication which is commonly known as the connected vehicles technology. The CVRL has previously worked on projects funded by the Northland Advanced Transportation Systems Research Laboratory (NATSRL), the Intelligent Transportation Systems (ITS) Institute, and the Center for Transportation Studies (CTS) of the University of Minnesota. Currently, CVRL is working in collaboration with Roadway Safety Institute (RSI) of CTS, and Savari Networks on two different projects funded by United Sates Department of Transportation (DOT). The CVRL is also working on a workzone safety project funded by Minnesota Department of Transportation. To find out the details on current and past research projects, please click here.
Outline

• Background
• What is DSRC?
• Why DSRC?
• Applications (V2I and V2V)
• Widespread Deployment Issues
• Summary
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Problem

• Safety
  • > 5 Million Crashes/year
  • > 2 Million injuries
  • > 30,000 deaths/year
  • Leading cause of death in ages 4 to 34

• Mobility
  • > 5 billion hours of travel delay
  • > $100 billion cost of urban congestion

• Environment
  • > 3 billion gallons of wasted fuel
Can Technology help?

- Dedicated Short Range Communication
- DSRC communication can “reduce, mitigate, or prevent 80% of crashes by unimpaired drivers” – US DOT
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DSRC Overview

- FCC has authorized 75 MHz of spectrum (5.850 - 5.925 GHz) for DSRC
- Supports both public safety and private operations
- Operates in both vehicle to vehicle (V2V) and vehicle to infrastructure (V2I) communication environments
Vehicle to Vehicle (V2V) environment
Vehicle to Infrastructure (V2I) environment
DSRC Infrastructure

- GPS Antenna
  - GPS
  - Internal Sensors
  - Driver Interface
  - Computer
  - DSRC Radio
  - DSRC Antenna
DSRC Message Types (SAE J2735)

- Basic Safety Message (BSM)
- Probe Vehicle Data Message (PVD)
- Traveler Information Message (TIM)
- Map Data Message (MAP)
- Signal Phase and Timing Message (SPaT)
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Unique Benefits

• Dedicated 75 MHz of spectrum @ 5.9 GHz
• Key Benefits
  • 802.11p technology similar to 802.11a
  • Low latency communication (<< 50 ms)
  • High data transfer rates (3 – 27 Mbps)
  • Line-of-sight, up to 1000 m and 360º
  • Low power message reception (< -90 dBm)
Range
Latency

<table>
<thead>
<tr>
<th>Communications Technologies</th>
<th>Least stringent latency requirement for Active Safety (1 sec)</th>
<th>Most Stringent latency requirement for Active Safety (.02 sec)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Two-Way Satellite (60+ secs)</td>
<td>WiFi 802.11 (3 − 5 secs)</td>
<td>Cellular (1.5 − 3.5 secs)</td>
</tr>
<tr>
<td>Terrestrial Digital Radio &amp; Satellite Digital Audio Radio (10 − 20 secs)</td>
<td>Bluetooth (3 − 4 secs)</td>
<td>WiMax (1.5 − 3.5 secs)</td>
</tr>
<tr>
<td>Traffic Signal Violation warning</td>
<td>Curve Speed Warning</td>
<td>Emergency Electronic Brake Lights</td>
</tr>
<tr>
<td>0.1s</td>
<td>1s</td>
<td>0.1s</td>
</tr>
<tr>
<td>Pre-Crash Sensing</td>
<td>Cooperative Forward Collision Warning</td>
<td>Left Turn Assistant</td>
</tr>
<tr>
<td>0.02s</td>
<td>0.1s</td>
<td>0.1s</td>
</tr>
<tr>
<td>Lane Change Warning</td>
<td>Stop Sign Movement Assistance</td>
<td>0.1s</td>
</tr>
</tbody>
</table>
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DSRC Applications

- V2V Safety
- V2I Safety
- CVO
- Private
V2V Safety Applications

Applications Enabled by BSM

• Forward Collision Avoidance (FCA)
• Emergency Electronic Brake Lights (EEBL)
• Blind Spot Warning (BSW)
• Lane Change Assist (LCA)
• Do Not Pass Warning (DNPW)
• Intersection Collision Warning (ICA)
• Wrong Way Driver Warning (WWDW)
• Cooperative Adaptive Cruise Control (CACC)
If driver of approaching vehicle does not stop, or slow down, a warning is issued within the vehicle.
Emergency Electronic Brake Lights (EEBL)

- High deceleration by vehicle approaching jam
- Trailing vehicle informed via DSRC within 100 msec.
V2I Safety Applications

Applications enabled by SPaT/MAP

- Red Light Running  RLR
- Left Turn Assist   LTA
- Right Turn Assist  RTA
- Pedestrian Signal Assist  PED-SIG
- Emergency Vehicle Preempt  PREEMPT
- Transit Signal Priority  TSP
- Freight Signal Priority  FSP
- Rail Crossing  RCA
Train 20-40 sec. distant

Conventional RR Grade Crossing Equipped with RSE

RSE warning range increased compared to conventional equipment

Can also be used at non-signalized crossings

Range up to 1100 ft

RR Warning Sign

Source: John Kenney, Toyota Info Technology Center
Work Zone Warning

In-Vehicle Display and Annunciation

DSRC RSU

Broadcast Coverage

Work Zone

Ending Location of Congestion

Starting Location of Congestion (Varying)

Starting Location of Congestion (Varying)

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CVO Applications

V2I and V2V applications
• Border Crossing
• Control Loss Warning
• Driver Log
• Fleet Management
• Freight, Inventory & Container Management
• Wireless Inspection
• Vehicle Diagnostics
• Weigh in Motion (WIM) Stations

Unique to CVO
Driver & Vehicle
• Vehicle Size
• Cab Environment
• Workload
• Duration
Private Applications

V2I and V2V applications

• Access Control
• Probe Data / Traffic Information
• Fuel / Drive-thru Management
• Parking Management
• Rental Car Transactions
• Service Record
• Vehicle Diagnostics
• Advanced TIS
Google Car

- Two million miles
- 90% of scenarios
Connected and Automated Vehicles

**Connected Vehicle**
Communicates with nearby vehicles and infrastructure; Not automated

**Connected Automated Vehicle**
Leverages autonomous automated and connected vehicles

**Autonomous Vehicle**
Operates in isolation from other vehicles using internal sensors

Image Source: Thinkstock/USDOT
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Widespread Deployment Concerns

- Privacy
- Security
- Positioning
- Scalability
Privacy

Privacy Concerns

• Information is abused
• Any 3rd party could track vehicle
• Authorities could track vehicle

Privacy is key element of V2X security

• No data tracking or trajectory logging of an individual vehicle
• Identifiers (certificates, MAC, etc.) changed every few minutes
• 1609.2 supports pseudonymous certificates – not linked to car
Security Concerns

Security Concerns
• Terrorists inject false messages or hack server, and people will be hurt
• There will be plethora of hoax or spam messages

Security is built into design
• Authentication – Shows sender is authorized and data not altered
• Encryption – keeps data secret
Positioning

- Which Road?
- Which Lane?
- Where in Lane?
- Relative Distance?

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Scalability

Will all this work here?
Summary

• Technology can help in future generation transportation systems
• DSRC has unique characteristics to enable future generation intelligent transportation systems
• DSRC works both in V2I and V2V environments providing many safety and mobility applications
• DSRC will facilitate connected autonomous vehicles
• There are some concerns in widespread deployment but the progress in technology and anticipated benefits will make it happen

Time for Questions?