DSRC and Connected Communications in the 5.8/5.9 GHz Band

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California PATH Program
-- The Pioneer of ITS

- Founded in 1986, a partnership between California Department of Transportation and University of California
- Founding Member of ‘Mobility 2000’ and ITS America
- Leading ITS research and development in the United States
- Research conducted by faculty and researchers statewide, with participation of industrial partners nationwide
Advancement of Mobile Communication Technologies

• Cellphone networks
  – 1980s, 1st Generation (AMPS, etc.)
  – 1990s, 2G, 2.5G, 2.75G, (GSM, CDMA, etc.)
  – 2002/2003, 3G
  – 2010, 4G (WiMax and LTE)
• Satellite communication
• Dedicated Short Range Communication (DSRC) for V2X
  – WiFi, Bluetooth, Dedicated Short Range Communication
In the Beginning: Dedicated Short Range Communications (DSRC)

1999: We are cognizant of the substantial efforts by both government and non-government entities to develop, in response to Congress’ transportation legislation, a national ITS plan and Architecture addressing ways of using communication technologies to increase the efficiency of the nation’s transportation infrastructure. The record in this proceeding overwhelmingly supports the allocation of spectrum for DSRC based ITS applications to increase traveler safety, reduce fuel consumption and pollution, and continue to advance the nations economy.

2003: The Commission adopted a Report and Order establishing licensing and service rules for the Dedicated Short Range Communications (DSRC) Service in the Intelligent Transportation Systems (ITS) Radio Service in the 5.850-5.925 GHz band (5.9 GHz band). The DSRC Service involves vehicle-to-vehicle and vehicle-to-infrastructure communications, helping to protect the safety of the traveling public. It can save lives by warning drivers of an impending dangerous condition or event in time to take corrective or evasive actions. The band is also eligible for use by non-public safety entities for commercial or private DSRC operations.
DSRC: 2004 FCC Ruling

- DSRC has 75 MHz Spectrum (1 control channel, 6 service channels)
- DSRC supports the non-exclusive geographic area licensing
  - Each licensee can operate any of the service channels
  - A license is for an area-of-operation (e.g., county, state…)
- Control channel is for safety messages and service announcements
  - Three levels of priority: Safety of Life, Safety, Non-Safety
- The service channels are used for non-safety related data traffic (e.g. e-commerce, infotainment)
- ASTM standards committee voted in 2000 to base it on 802.11a
  - Now IEEE 802.11p
DSRC for Transportation

DSRC can enable new transportation applications

- Vehicle to Vehicle (V2V)
- Infrastructure to Vehicle (I2V)

Key Milestones

- 2012-2013 USDOT sponsored Safety Pilot in Ann Arbor to collect data for supporting USDOT decisions on DSRC
- 2013 - NHTSA Decision on Vehicle Communications for Safety (light vehicles)
- 2014 - NHTSA Decision on Vehicle Communications for Safety (heavy vehicles)
- 2015 - FHWA to issue Infrastructure Implementation Guidance
V2V Applications

• A wide range of applications are being explored:
  – Cooperative Adaptive Cruise Control
  – Cooperative Collision Waning
  – Cooperative Intersection Collision avoidance
  – … …

• Deployment will be driven through USDOT’s Connected Vehicle program, state and local agencies and private industry
Cooperative Adaptive Cruise Control (CACC)

- CACC extends from Adaptive Cruise Control (ACC) with the addition of V-V communication (DSRC); 2004-2010
- Potential increase in roadway efficiency without compromising safety
- Pilot Evaluation of driver experience
  - Two Nissan Infinity FX-45
  - ACC time gaps of 1.1 to 2.2 seconds
  - CACC time gaps of 0.6 to 1.1 seconds
- 5.9 GHz DSRC, Denso WRM, 10 Hz Communication
I am here. Are you there?

V2V Engineering:
Intersection Collision Warning System

WiVEC Panel @ Baltimore, Oct 1, 2007

Source: VSC GM Presentation
I2V Applications

• Safety applications
  – Intersection collision avoidance (red light, stop sign, gap, pedestrian)
  – Speed warnings (curve, workzone, traffic condition, school, weather, variable speed)

• Dynamic mobility applications
  – Dynamic ramp metering
  – Next generation intersection control (e.g. TSP)
  – Congestion pricing

• Motorist aid applications
  – Onstar-like functions, through Message hopping for roadside emergency notification
Situation Awareness Example

- 60% of rear-end type collisions have been reduced at Sangubashi Curve.
Situational Awareness: California Experiment
Bay Bridge, S-Curve
Trigger Points for Speed Alerts

Auditory & Visual Alerts
Vehicle Infrastructure Cooperation - Pedestrian Alert Test Scenarios

- Approaching Vehicle
- Controller Cabinet
- Wireless (DSRC)
- Pedestrian Crossing
- Pedestrian Sensor Poles
Energy/Emissions Minimization

Single Intersection Optimization with Signal Phase and Timing Information

**advanced signal information can help reduce intersection-influenced fuel consumption** by 14% for cars and 12% for trucks

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**reference:**
Automated Driving

(1997 NAHSC Demonstrations)
A ‘Future’ Example: DSRC Enabled Transit Applications
Transit AVL/Advanced Communication System

- Mobile communications every 1-2 minutes
- GPS-based automatic vehicle location (AVL)
- Computer-aided dispatching (CAD) and two-way messaging
- Real-time information for travelers
- On-board voice announcements and digital signs advise passengers of next stops
- Arrival/departure signs and voice annunciators at bus stops or rail platforms provide travelers with up-to-the-minute schedule information
AVL/ACS = ‘Transit Connected Vehicles’?

- Low bandwidth communication (1-2 minutes) can not support real-time applications
- Disintegrated systems: At least 3 systems use the same bus position information but with 3 positioning and communication devices
  - Automated Vehicle location/Advanced Communication System
  - Next Bus arrival information
  - Signal priority
Transit AVL/Advanced Communication System

Dedicated Radio

Data Processor

DCC

Internet

WAN

Users via Web Browser
DSRC based I2V for Transit Management

- Backhaul Comm.
- Data Adaptor
- Internet
- Data Proc. Processor
- WAN
- RSU
- DSRC Radio
- Users via Web Browser
- TMC Server
- ATM Router
- TMC LAN

Web Browser Interface

Internet Cloud

Transit Management Center
DSRC based V2I Transit Signal Priority and Traveler Information System

Internet

Traffic Management Center

Backhaul Comm.

Controller

NEXT BUS IN 5 MIN

TMC Server

ATM Router

TMC LAN

RSU

DSRC Radio
Bus-as-Probe: Fused bus movement with arterial traffic signal data to derive arterial travel time
IntelliDrive to Change ITS Deployment Practice

- Consolidate all mobile communication needs with IntelliDrive (potentially fused with a low bandwidth comm. link)
- Support integrated, scalable architecture
- Significant cost savings to transit agencies
V2V Improves Transit Safety
Forward Collision Warning
Vehicle Following Behavior: Cumulative Time Gap
Urgent Needs For Transit Connected Vehicles

• IntelliDrive offers opportunities for innovating transit mobility and safety
• Transit is behind in IntelliDrive, national efforts are needed to
  – Produce evidence for the safety benefits of transit IntelliDrive applications through establishment of transit IntelliDrive safety scenarios
  – Define how IntelliDrive can improve transit operation and offer travelers with better connectivity and reduced travel time; and how IntelliDrive can facilitate coordinated management among transit, arterials and freeways
• To develop, test and incorporate requirements for transit IntelliDrive applications in order for transit needs to be incorporated in IntelliDrive related framework (messages, standards, and protocols)
Summary: Significance of DSRC – Connected Vehicle Technology

- Mobile communication and applications have advanced at an unprecedented pace
- A communication infrastructure overlaid on the existing road infrastructure, will enable:
  - Rich sets and high validity data
  - V2V and I2V based safety and mobility applications
- Connected Vehicle Technology can lead to new ways of operating transportation systems
California ‘Connected Vehicle’ Testbed

El Camino Real (SR-82)
Questions

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