

Demo: Real-time Vehicle Movement Tracking on Android Devices through Bluetooth Communication with DSRC Devices

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Abstract—This demo paper describes the architecture and communication protocols—both single hop and multi-hop—for DSRC devices. The paper also describes an Android application that enables visualization of real-time vehicle movements on Google map using DSRC and Bluetooth communication. The application receives information about position, speed and direction of mobility that multiple vehicles obtain through the GPS Receiver attached to their DSRC OBU. The android application communicates with one of the DSRC units through Bluetooth to gather real-time traces collected from all DSRC-equipped vehicles. The application displays live movement of these vehicles on Google map with their path history, speed and direction. The source code and installation files of this application will be released through the Open Source Application Development Portal (OSADP) hosted by the U.S. Department of Transportation. (*Abstract*)

Keywords—DSRC, Bluetooth, Android, V2X, real-time monitoring (*key words*)

I. INTRODUCTION

Vehicle-to-everything (V2X) communication—enabled by DSRC technology—opens a great premise of safety, alerts, and assistive services for drivers on roads. This technology allows a vehicle to send its position, speed, direction of speed, brake status, and other information to nearby vehicles and infrastructure. However, current aftermarket DSRC devices manufactured by the authorized vendors of US Department of Transportation do not include any built-in graphical user interface integrated with the device. This requires additional development efforts to incorporate human machine interface through smartphones or tablets that would cause less distraction while driving.

Efficient multi-hop communication protocols are required for timely dissemination of information and real-time forwarding of packets. Unfortunately, most of the current after-market DSRC devices do not provide the necessary SDK support or APIs related to multi-hop V2X communication. In this demo paper, we incorporate both single hop and multi-hop communication protocols for vehicular communication. Some of the key contributions involved in this application development includes development of the OBU transmission

application that broadcasts the GPS trajectories, the OBU receiver application hosting a Bluetooth server and the Android application displaying the trajectories on map. The application has been tested in a small-scale Connected Vehicle (CV) testbed facility—jointly managed by the University of Tennessee and East Tennessee State University—using the DSRC devices manufactured by one of the authorized vendors of the U.S. Department of Transportation.

II. RELATED WORK

The Federal Highway Administration of the U.S. Department of Transportation has initiated the Open Source Application Development Portal (OSADP) [1] for releasing connected vehicle applications. Software developers, researchers and ITS practitioners can utilize this portal to address the application needs for state and local transportation agencies. As of now, several ITS applications have been released through OSADP which use the V2X data in some way to offer assistive services, data analysis, and monitoring option through smartphones. For example, LANE-CHANGE [2] application aids in lane change maneuver using cooperative adaptive cruise control. MMITSS-AZ [3] provides real time adaptive signal control for allocating green signal time for emergency and transit vehicles. The MMITSS-AZ application also provides a smartphone application for disabled pedestrians to make a pedestrian signal request for crosswalk. A vehicle monitoring service for weight station is presented in SRI 1.0 [4]. Various analysis applications (e.g. motion analysis, security analysis, driving behavior analysis, etc.) are also presented in CloudThink Motion Logger [5], security analysis [6], SmarTrAC [7]. None of the above applications use Bluetooth connectivity of smartphones with DSRC devices to visualize the vehicular trajectories and speed on a map. In addition, none of these applications use multi-hop V2X communication.

III. SYSTEM DESIGN AND COMMUNICATION PLATFORM

Our application has four major components: (i) a transmission application, (ii) a receiver application with a Bluetooth server, (iii) an Android application, and (iv) a set of communication protocols. Figure 1 shows the communication between an Android device and one or more DSRC devices. Figure 2

shows how the real-time movement of a vehicle is displayed using the single hop communication.



Figure 1. Bluetooth communication between Android and DSRC devices

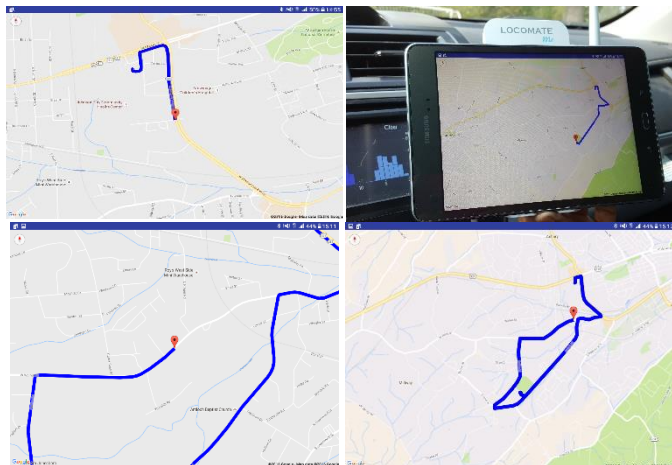


Figure 2. Real-time vehicle movement displayed on Android tablet

A. OBU transmission application

The transmission application, specifically the OBU transmission application sends a vehicle's position, speed, heading direction, mac address, and timestamp. The mac address is sent to categorize and separate packets in the recipient end. The following steps are followed to develop the transmission application:

- Registering a provider with a PSID (Provider Service Identifier) and PST (Provider Service Table) entry.
- Building WSM (Wave Short Message) packets using channel, channel rate, channel power, version, security, PSID, priority, and message data.
- Preparing message data that contain time, latitude, longitude, speed, latitude direction, and longitude direction.
- Transmitting the WSM packets using `txWSMPacket()` function.

B. OBU receiver application with a Bluetooth server

The receiver application receives packets from other OBUs within its range. The receiver application also acts as a Bluetooth server to send the received packets to the connected smartphone. The following steps are followed to develop the receiver application:

- Registering a user with a PSID and a PST entry.
- Creating a Bluetooth server using RFCOMM socket.
- Receiving packets using `rxWSMPacket()` function.
- Developing a server thread for writing the received packet data to a smart phone.

C. Smartphone application

The smartphone application is the visual representation of surrounding vehicles- their positions, speeds and directions. The application also tracks the position and other dynamics of the vehicle to which the smartphone is connected. For visual representation, google map API is used. The following steps are followed to develop the smartphone application.

- Creating a client socket using RFCOMM client socket.
- Creating Bluetooth discoveries to connect with Bluetooth devices.
- Creating a client read thread that reads the GPS data from OBUs and updates the map by drawing trajectory line, updating marker and camera.

D. Communication protocols

We developed both single hop and multi-hop communication protocols to transfer packets between DSRC devices. A brief description of each of these protocols is given below:

- *Single hop*: A source DSRC device exchanges packets directly to a target DSRC device within its range using the single hop communication protocol. In this scenario, both the source and target DRSCs must be present within a range of 300m radius.
- *Multi-hop*: When the source and target DSRC devices are not within the transmission range, they communicate through one or more intermediate forwarding nodes (intermediate DSRCs). An internal routing table is maintained that stores the mac address, position, distance, and a timestamp for each surrounding vehicle (i.e. DRSC).

IV. CONCLUSION

Our current application describes the architecture and communication protocols for an Android application that enables visualization of real-time vehicle movements on Google map using DSRC and Bluetooth communication. Our future efforts will focus on developing a DSRC-based taxi-hailing application [8] that will utilize both single-hop and multi-hop communication protocols developed through this current research project. It is anticipated that this taxi-hailing application will be further integrated with the IDTO application package [9] and deployed through NYC Connected Vehicle pilot project.

REFERENCES

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