Boston University
Electrical & Computer Engineering
EC 463 Senior Design Project

First Prototype Testing Plan

Over-the-Air C-V2X Communications on Software Defined Radios

by

Team 13
C-V2X Misbehavior Detection System

Team Members

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Required Materials

Hardware:

- 3 x DragonOS (Lubuntu) PCs
    - 8 Cores
    - 16 gb RAM
- 3 x NI 2901 USRP
- 2 x Wall power adapters
- 5 x Vert 2450 Radio Antena
- 2 x Keysight 33500B Waveform Generator
    - 1 x 1 MHz, Pulse Wave
    - 1 x 10 MHz, Square Wave

Software:

- SrsRAN Library
    - SrsEPC
    - SrsENB
    - SrsUE
- GQRX
- Bash commands
    - ping
    - iperf

Set Up

At the core of this project are three NI 2901 USRPs, which are connected to a variety of devices for efficient, stable communication. Two of the USRPs will model end-to-end communication, and the third will monitor network traffic. Each of the communicating USRPs is plugged into the wall to get a consistent 1A, as propagating a signal in the 5.9 GHz range requires a high, consistent flow of power. All of the USRPs are connected to our desktop computers running DragonOS, an Lubuntu variant that specializes in radio software. This USB connection enables us to use the SrsRAN library to configure the radios through software. From here, everything from the frequency band to the envelope itself can be digitally sent to the SDR. The base station and user end USRPs will be connected to both a signal generator at 10 MHz and a signal generator at 1 Hz to synchronize communications. The base station SDR will run SrsENB and SrsEPC to serve as the virtual network base for the other USRP devices to connect to. The user end will run SrsUE, functioning as a communicating node to the base station. The third USRP will currently function as our data collecting node, monitoring the frequency on which the downlink and uplink are situated.

Pre-testing Setup Procedure

1. Connect the Base Station and User End USRPs to power sources and separate computers.
2. Ensure these USRPs have been properly connected and are visible to the computer by running `uhd_find_devices` on the command-line. Look for the device name “b200.”
3. Configure signal generators with the following settings:
    a. A “Pulse, Off, 50 Ohm” wave that is an “AM modulated by sine” wave, frequency of 1 Hertz, amplitude of 10 dBm.
    b. A “Square, Off, 50 Ohm” wave that is an “AM modulated by sine” wave, frequency of 10 Megahertz, amplitude of 100 millivolts (this should probably be 10 dBm).
4. Connect the base station and user end USRPs to both signal generators. Ensure that each signal generator is connected to the same relative input on each USRP.
5. Open up a terminal on the base station; run `srsepc` and `srsenb`.
6. Open a terminal on the user end and run `srsue`.
7. Activate the trace on the User End and Base Station.

8. Connect the monitor USRP to the computer hosting the Base Station.
9. Open Wireshark on the PC attracted to the monitor.
10. Open GQRX on the PC attached to the monitor. Configure it to read data from the monitor by checking “Ettus B200” in “File => I/O Devices” and typing “ctrl+D.”
11. Flag uplink frequency 2.560.000.000 and downlink frequency 2.680.000.000 for ease of access during testing.

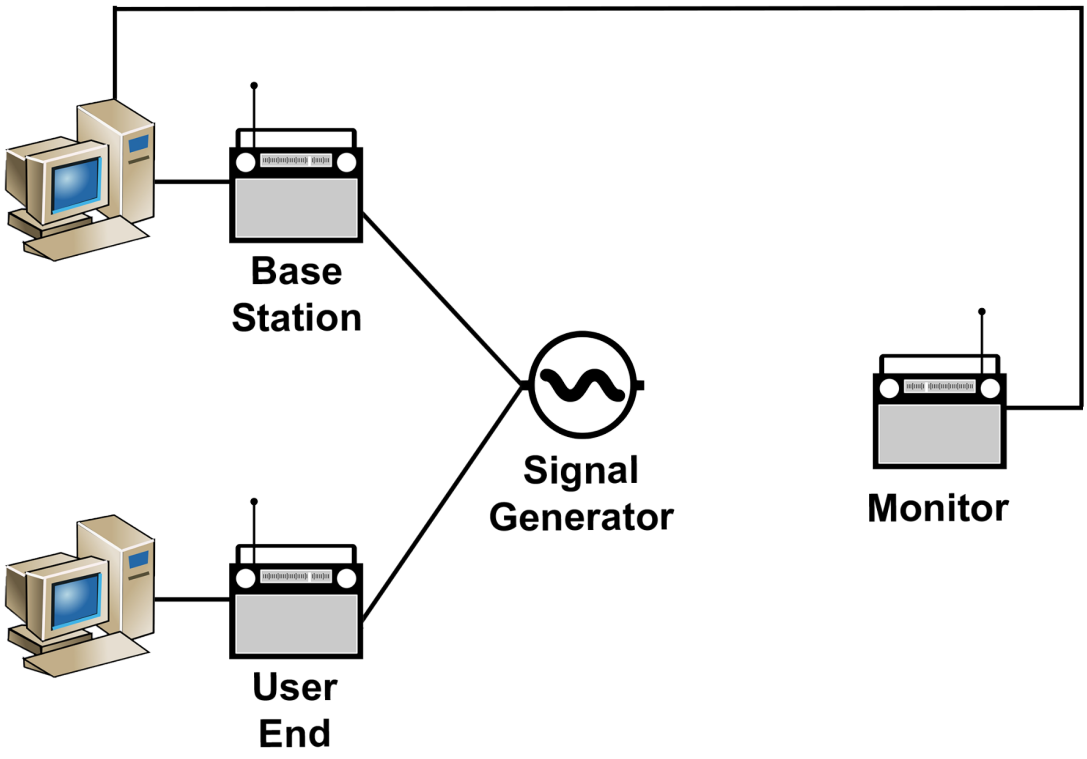

Figure 1: Illustration of Setup

Testing Procedure

1. Demonstrate uplink communication between USRPS using the SRS radio suite.
    a. Run `ifconfig` on the Base Station and record the ENB IP.
    b. Run `ping {ENB IP}` on the User End.
    c. Run on the `iperf -s` Base Station and `iperf -c {ENB IP} -t 20s` on the User End
    d. Repeat Step 1c with `iperf -c {ENB IP} -P 20 -t 20s` on the User End.

2. Demonstrate downlink communication between USRPS using the SRS radio suite.
    a. Repeat steps 1a-1d, but reverse the roles of the User End and Base Station

Troubleshooting Procedure

There are errors that can arise with connectivity when running the demo. A few are highlighted below.

1. "/usr/src/srsRAN/lib/src/phy/rf/rf_uhd_imp.cc:1335: USRP reported the following error: EnvironmentError: IOError: usb rx6 transfer status: LIBUSB_TRANSFER_ERROR" when running the base station command.
2. "Connect failed: Operation now in progress" when running iperf.
3. The iperf/ping statistics are returning 0 for the bitrate (`brate`). This indicates that the UE (user equipment) and ENB (base station) are not connected. This can occur if the system is left idle for a period of time, e.g. no iperf/ping program running.

To resolve these issues, try the following:

1. Teardown: Kill the terminal processes in the order of `srsue`, `srsenb`, `srsepc` and restart them in reverse order.
2. If step (a) does not work, power cycle the USRPs (turn them off and unplug the USB and power cables).

Measurable Criteria

1. The Base Station and User End USRPs should be able to communicate both uplink and downlink.
    a. When running ping/iperf:
        i. Connection should begin between the ENB and UE.
        ii. There should be incoming and outgoing ICMP/TCP packets on Wireshark.
        iii. There should be nonzero bitrates in the ENB and UE trace output.
        iv. Uplink bitrate should be higher for uplink communication and vice versa.
        v. Both the red and green LEDs should be on for both USRPs.
2. The Monitor USRP should be able to see traffic between the ENB and UE.
    a. GQRX should see activity on the uplink frequency (2.560.000.000 Hz) and downlink frequency (2.680.000.000 Hz) during ping and iperf execution.

Score Sheet

Test	Connected	Wireshark Packets	Nonzero Trace	Bitrate Order	Red LED	Green LED	Monitor (UL)	Monitor (DL)
Ping (UL)								
Iperf, 1 connection (UL)								
Iperf, 20 connections (UL)								
Ping (DL)								
Iperf, 1 connection (DL)								
Iperf, 20 connections (DL)								