An assessment of the impact of unregulated transmissions on Intelligent Transportation System communications at 5.9GHz

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Abstract

Since the FCC's controversial decision to adjust the spectrum allocation for intelligent transportation systems in November 2020, the need for targeted research has grown. There has been a wide range of changes implemented by the FCC with both the removal of 45MHz from existing spectrum allocations and the transition away from DSRC to C-V2X needing to be studied in greater detail. In this paper, we aim to explore the effects of these decisions by examining the potential impacts on commercial grade V2X hardware in a real-world complex radio environment. We will do this by characterizing both DSRC and C-V2X and comparing their performance to each other in several radio environments with different types of interference present. This will allow us to decide as to whether the rule change allows V2X to continues to provide for current and future ITS applications.

Important Terms

- ITS: Intelligent Transportation System
- V2X: Vehicle to Everything
- DSRC: Direct Short Range Communication
- C-V2X: Cellular Vehicle to Everything

Introduction

As cars make advances in sensing and computing systems the need for a dedicated communication standard has arisen due to the unique conditions faced by vehicles. In response to this need, the FCC allocated 75MHz of bandwidth for intelligent transportation systems (ITS). This spectrum from 5.85 to 5.925MHz was to be used by ITS to enhance the operational safety of roadways in the United States. These rules dedicated this spectrum to Direct Short-Range Communication or DSRC a WLAN based V2X solution, they also created seven 10MHz channels for use by the technology within the band. This early reservation was intended to create an environment that would foster research and innovation in the industry-leading to widespread adoption of ITS.

In the twenty years since the reservation, there has been limited investment in V2X. A 2019 report from the Congressional research service stated, that across the United States only 52 DSRC implementations are operational. This lack of adoption prompted the FCC to issue a rule change in 2020 reallocating the lower 45MHz the previously allocated band to unlicensed WiFi transmissions. In order to produce a single 160MHz block of dedicated spectrum for WiFi once combined with existing 5GHz allocations. This rule change also officially transitioned the remaining 30MHz of the band for C-V2X a cellular solution from 3GPP. The motivation for this change has been investments in the industry in supporting the technology. The FCC also stated that it expects C-V2X to provide more robust connectivity for ITS as opposed to DSRC.

In this project, we aim to quantify the impact the rule change will have on the quality of communication achievable with both DSRC and C-V2X in the remaining band with adjacent unregulated transmissions. As well as examining the observable differences between DSRC and C-V2X connections. This will allow us to either support or refute the FCC's assertion that C-V2X presents the more robust solution and the decision to transition away from existing DSRC implementations is correct.

To do this we will first create a system that can reliably and consistently produce unregulated interference in the band, given that no commercially available equipment is currently available for the band in the United States. We will then begin to test several commercial V2X solutions, both DSRC and C-V2X, made available to us through a partnership with the Utah Department of Transportation. Through a series of over-the-air (OTA) tests, we aim to quantify any observable differences between the technology both with and without introduced interference. This data will allow us to verify that the recent changes do not interfere with the band's original purpose of enhancing safety.

Project Goal

Complete thesis research project and publish results

Proposed Methods

How are we going to deal with the problem

- Develop testing methodology to generate consistant interference levels at 5.9GHz
- Setup and gather baseline information with commercial V2X hardware
- Make a conclusion as the impact of unregulated interference on V2X operations

What resouces do we need to reach the goal

- SDRs and various radio and compute equipment, provided by advisor through the POWDER platform
- Commercial DSRC and C-V2X equipment, aquiring through partners at UDOT

What are the potential risks involved? Any mitigation/contingency plans?

- Having others publish similar results before we can get paper out
- UDOT unable to provide C-V2X hardware, will just have to publish with DSRC results
- Not getting paper accepted into desired conference

How long does each method take?

- Develop proof of concept and ensure methodology: 1 - 3 Weeks
- Get access to and configure commercial equipment: 1 - 2 Weeks
- Conduct testing and gather performance data: 1 - 2 Weeks
- Analyze findings and write thesis paper: 1 - 2 Weeks

What is the job distribution plan for each team member?

- Thesis Student: Jacob Bills
- Thesis Advisor: Kobus Van der Merwe

What is the communication plan for the project?

- Bi-weekly standup meetings with advisor for quick updates and questions
- Weekly in-depth meeting with advisor to determine goals for next week

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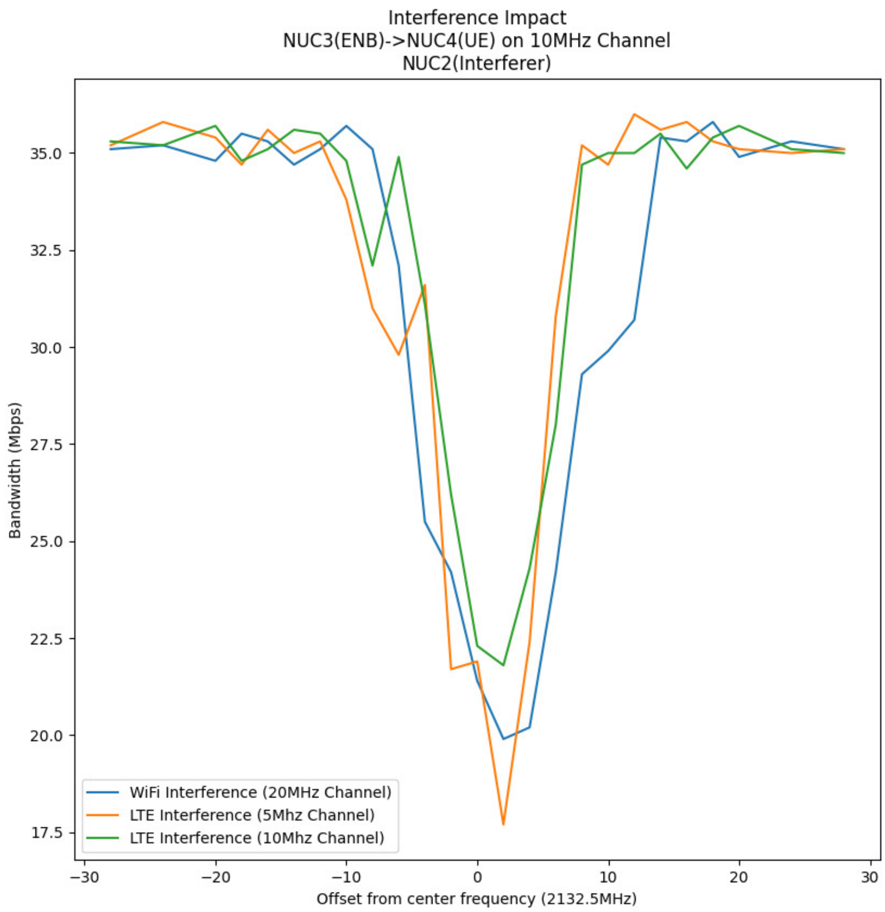
Timetable

- ~~Week of 2/26: Ensure conformity in interference power levels~~
- ~~Week of 3/05: Generate LTE captures and run proof of concept testing~~
- Week of 3/12: Continue proof of concept testing
- Week of 3/19: Compile results to present ensuring proof of concept
- Week of 3/26: Install UDOT DSRC equipment within POWDER
- Week of 4/02: Install UDOT DSRC equipment within POWDER
- Week of 4/09: Run interference testing on DSRC
- Week of 4/16: Run interference testing on DSRC
- Week of 4/23: Compile results and determine inpact on DSRC
- Week of 4/30: Format data and form a conclusion as to the impact on DSRC

Early Proof of Concept Results



As a proof of concept to ensure we can accurately capture and re-transmit a signal we captured an active 10MHz LTE link on the PhantomNet testbed, which would be analogous to a C-V2X link. Two of the nodes make use of srsLTE software, i.e., srsENB and srsUE, to create a custom LTE network to be recorded by the recorder node. The recorder node makes use of GNU Radio to capture 50M~Hz of the spectrum centered at the downlink frequency (2132.5MHz) of the LTE link.

We captured the whole 50MHz surrounding the 10MHz signal to ensure we captured any transmission roll-off.

We also placed the LTE link under a sustained load, while the capture was taking place, thus ensuring that the UE does not enter an idle state. To do this we made use of a iperf3 session to transfer data across the link (in a downlink direction) and record the bit-rate achieved. We also monitored the connection using the uhd_fft, which allows us to observe the power-levels at and around the transmission frequency. The figure to the left show the performance impact of interference played back at different frequencies relative to the LTE center frequency.

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