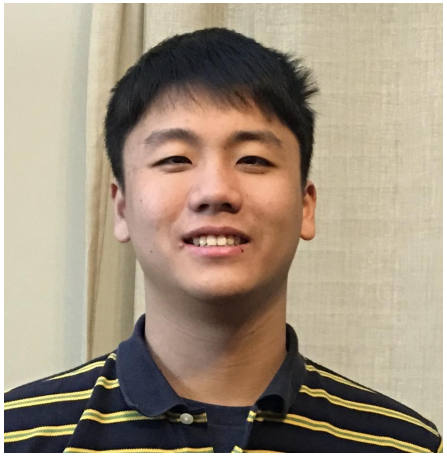
2021 WINLAB Summer Internship

8/06/2021

Distributed spectrum sensing and channel assignment



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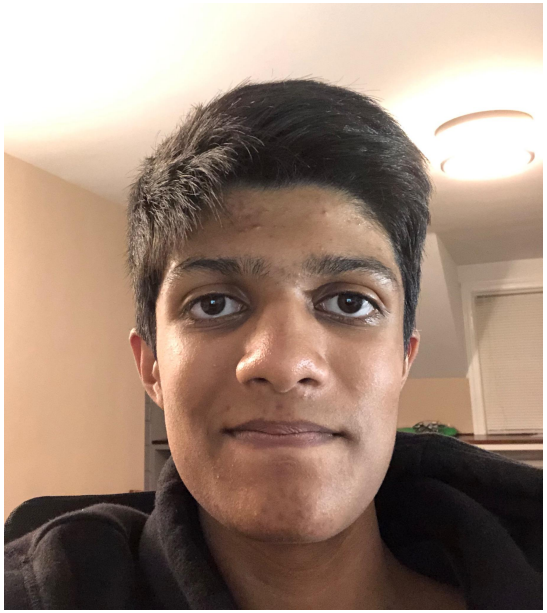

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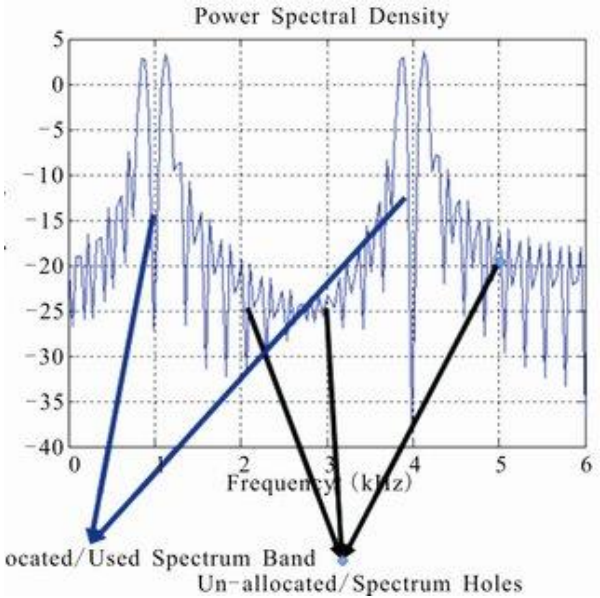
Problem

- The radio spectrum is usually allocated via licensing to certain bands
- However, many of the bands are over or underutilized, leading to inefficient spectrum usage.

- The graph on the right is an example of “holes” in part of the spectrum



Cognitive Radio (CR)

- Cognitive Radio solves this problem by dynamically using the best channels available.

- This way, there is no interference to the licensed user, and the spectrum is utilized much more efficiently.

- Two of the most common methods include energy detection and the use of artificial intelligence.

Cognitive Radio Steps

- Spectrum Sensing
  - Observing the current spectrum use and collecting that data to analyze.
- Spectrum Analysis
  - The “cognitive” part. Use of AI/numerical formulas to use the sensed data and make a decision on what to do.
- Channel Assignment
  - Using the results of spectrum analysis to send signals at the correct frequency

Terms

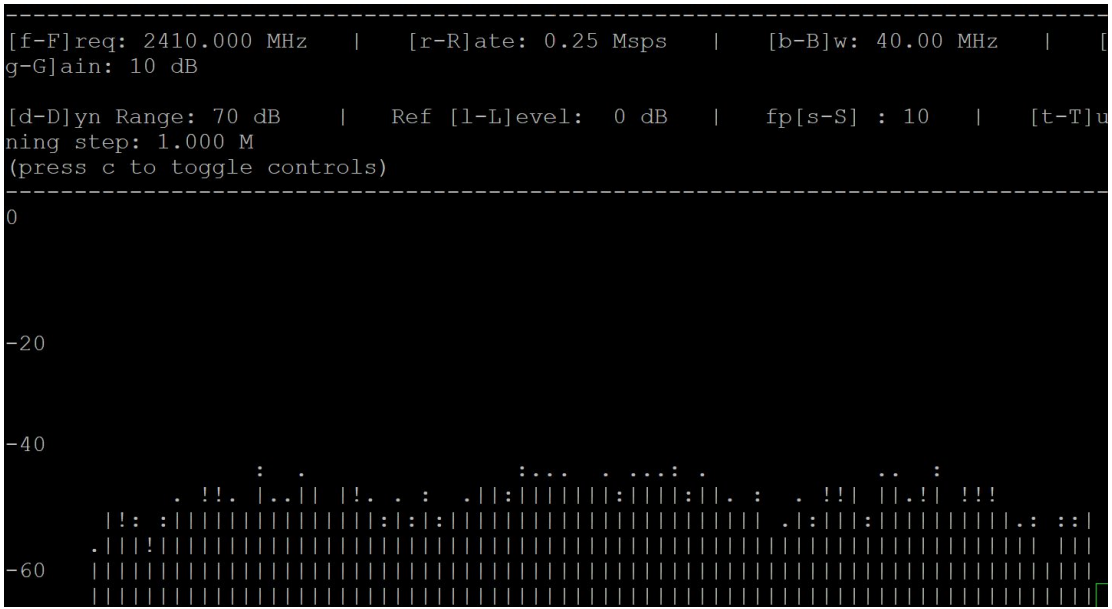
- SDR - Software Defined Radio
  - A radio in which processing of the signal which is usually done through hardware components (mixers, filters, etc.) are instead implemented through software.
- USRP - Universal Software Radio Peripherals.
  - The specific family of SDRs on a selection of ORBIT nodes.
- UHD - USRP Hardware Drivers
  - The drivers used to communicate with the USRPs on each node.
- GNU Radio
  - Another piece of software used to configure the USRPs on each node for frequency, sampling rate, etc. and any other transformations to be done on the transmitting or receiving end.

Experiment - Hardware

- Nodes with USRPs on the ORBIT network were used to model cognitive radio nodes.
- Below is a USRP X310, which we used in our experiments.

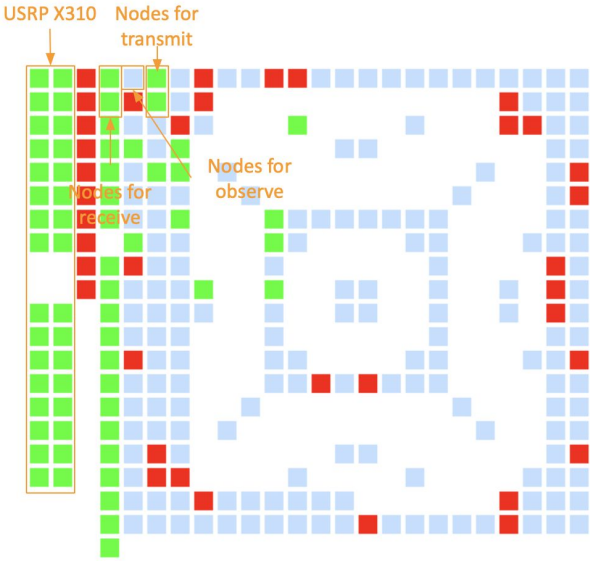
Experiment cont.

- We started with the USRPs to send and receive signals with customized transmission parameters across the ORBIT network, and listen on other nodes



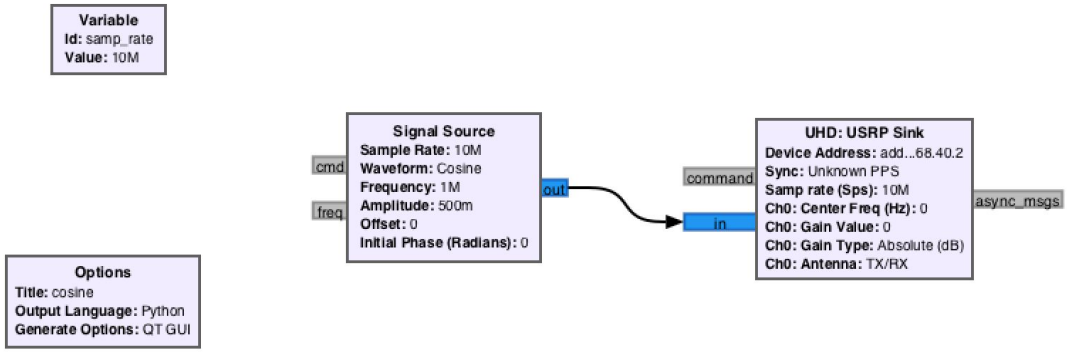
Experiment cont.

- We ran a data collection experiment using the python GNU Radio APIs on the grid subdomain.
- Setup consisted of transmitter, receiver, and observer nodes
- Collected basic data into files for later analysis



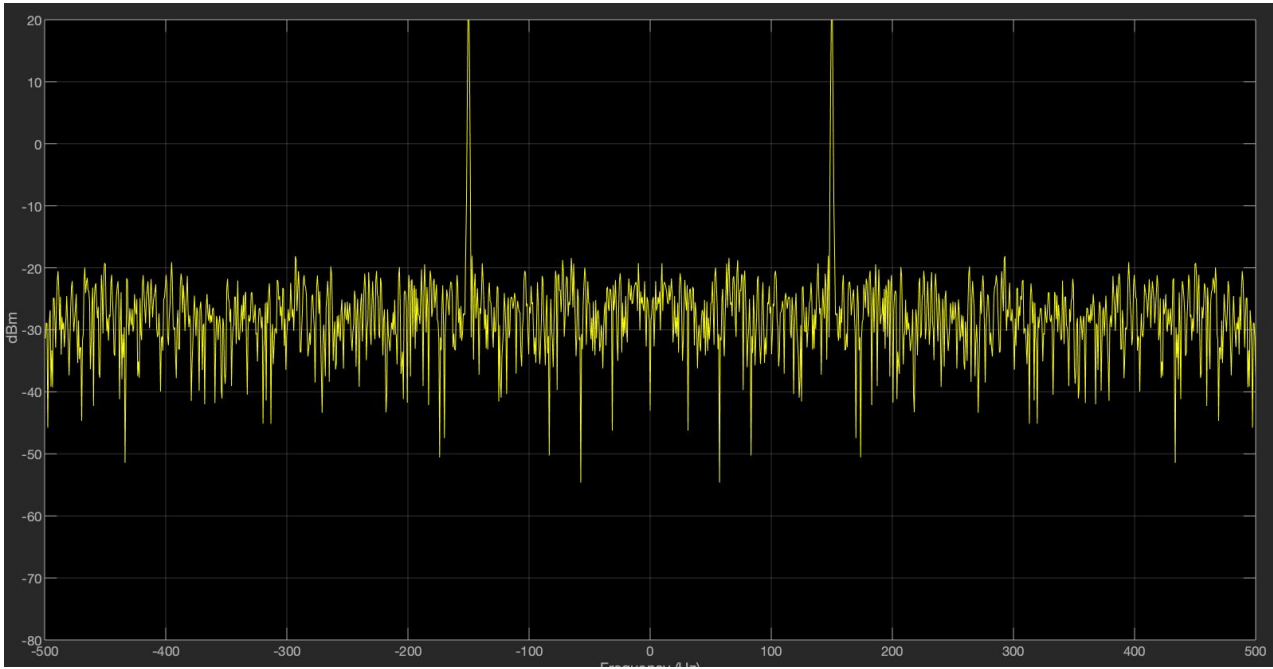
Another approach: Simple GNU radio using USRP

- Cosine wave
- Sample rate at 10MHz
- Frequency 1MHz
- Amplitude 0.5



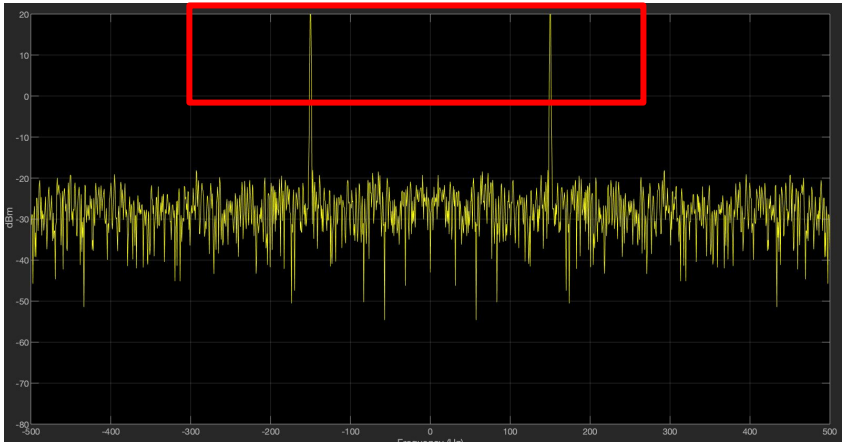
More on experiment

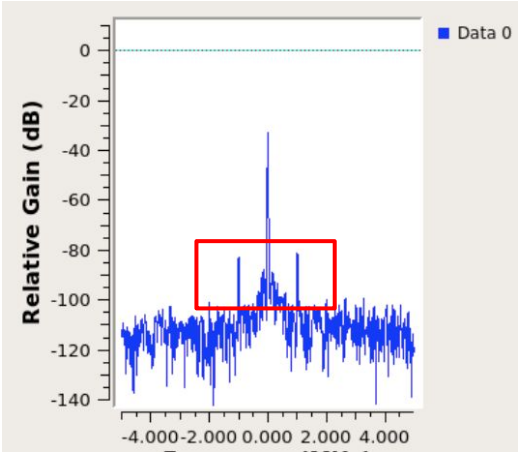
- Using MATLAB to simulate the signal transmission in USRP
- In frequency domain
- Cosine wave with noise
- Two peaks at -150Hz and 150Hz



Simulation vs. Real USRP Devices

- Both have peaks on positive and negative frequencies, because of the cosine wave.
- In the real USRP, there is a peak at 0Hz, which is due to a DC offset of the received signal.





Next Steps for Future Projects

- With enough collected data and the correct metadata, training an artificial intelligence could be feasible. However, it would require much more data than we were able to collect.
- The use of more complex GNU Radio operations to perform the necessary calculations for the energy detection approach
- Possibly implementing or finding an implementation for the IEEE standard for cognitive radio, though a full implementation would be difficult to complete in 2 weeks

Questions?