Programmable Metamaterial Antennas for Physical Layer Security

RUTGERS
WINLAB | Wireless Information Network Laboratory

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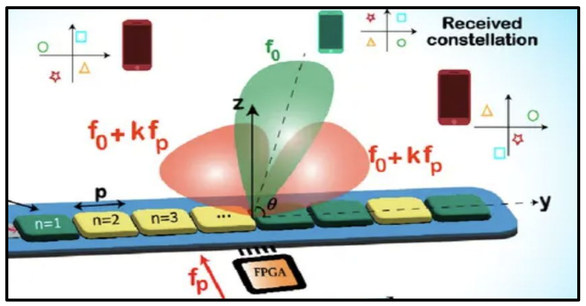
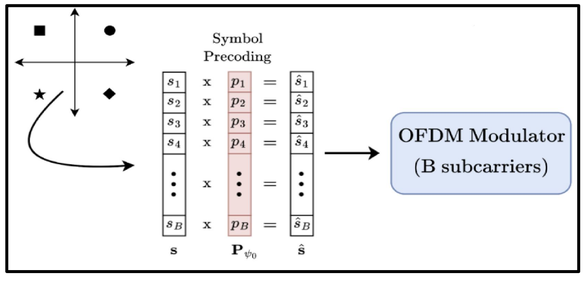
Motivation

- With the advent of the **Internet of Things (IoT)** revolution, there is an increasing need to develop **low-cost physical layer security** protocols for devices.
- Even a minor reduction in required computational power or costs could **propogate savings to tens of billions of IoT devices** .
- This project proposes a **computationally simpler** solution using **Metamaterial Antenna Arrays** that scramble signals for eavesdroppers from unwanted directions. This technique is known as **Directional Modulation** .



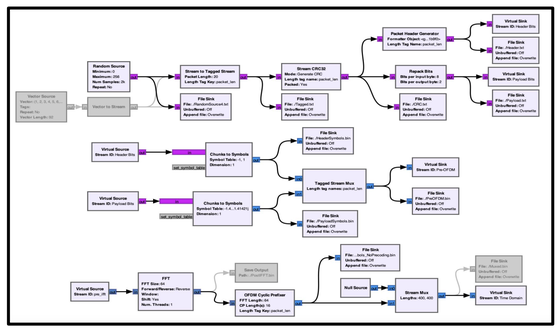
Symbol Precoding

- Previous research has proven that Directional Modulation can successfully and securely transmit **low bandwidth signals** .
- Issues arise as larger amounts of data are transmitted, requiring wider bandwidth. The **properties of the Metamaterial Antenna differ depending on the frequency** of the signal.
- As this scheme relies on **OFDM** signals with 64 subcarriers spaced orthagonally in frequency, the **signal will be affected by the MTM antenna nonuniformly** , resulting in errors.
- The solution to this problem and the focus of the team's research this summer is called **Symbol Precoding** .
- This is a technique where the information is multiplied by a **Precoding Vector** before transmission, accounting for the effects of the antenna.



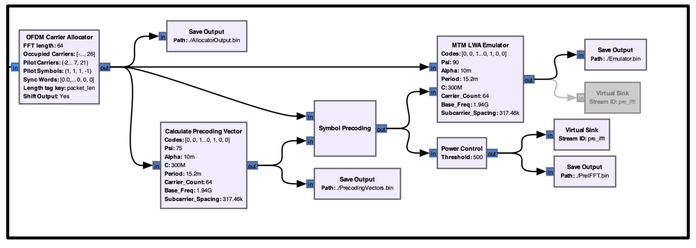
GNU Radio

- GNU Radio is a free toolkit that provides signal processing blocks to implement **software-defined radios** and signal processing systems.
- GNU Radio allows the creation of **custom blocks** in Python which can be programmed for tasks that are not provided by default.



Objectives

- Investigate the existing implementation of the OFDM Transmitter in GNU Radio to **determine at what stage Precoding should be performed** .
- Create **custom Python blocks** in GNU Radio to **implement Symbol Precoding** .
- Simulate transmission and receieval of packets on software to **ensure validity of system** .
- Perform experiments in an Anechoic Chamber to **prove that Symbol Precoding is an effective solution** .



Acknowledgements

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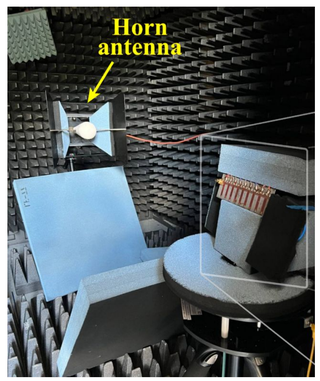
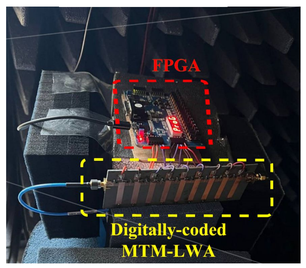
Experiments

- Many tests were performed in the **Anechoic Chamber** in the Electrical Engineering building at Rutgers.
- The Metamaterial Antenna was placed on a **rotating platform** to simulate the transmission of signals from **different angles** .
- A **USRP B205 Mini-i** was used to inject the precoded signal into the MTM Antenna, and a **Horn antenna** was used to receive it.





Results

- By the end of the summer, the team had **successfully implemented Symbol Precoding** in GNU Radio as well as **verified the system** through software simulation.
- The real world experiments that were performed resulted in a single digit percentage of the transmitted packets being **correctly received** .
- While further tuning is necessary, **this small percentage is no accident** , and is a proof of concept showing that **Symbol Precoding is possible** .

Transmitted at 90°:
2.82842 + 0.0000j
-4.12322 + 11.220j
-2.35175 +2.9035j

Observed at 30°:
1.85419 - 1.44246j
1.80198 + 9.10153j
-0.40089 + 3.1299j

Observed at 90°:
2.82842 - 9.73811e-08j
-4.12322 + 11.2208j
-2.35175 + 2.90354j

Future Work

- Further experimenting to **ensure reception of all packets** .
- **Automation** of the experiments performed in the Anechoic Chamber using Python scripts to **control antennas with precision timing** .

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