DATA OFFLOADING IN 5G WIRELESS NETWORKS

John Heggland, Electrical Engineering

Mentor: Dr. Ahmed Ewaisha, Lecturer

School of Electrical, Computer and Energy Engineering

BACKGROUND

User to user data relays reduce the burden on base stations, increasing wireless network performance and reliability. In theory, each transmitter-receiver pair has its own unique channel that must be estimated and accounted for during transmission. The aim of this project is to take knowledge of the channel at two separate receivers, and develop a neural network framework to allow successful data relays between users.

Software Defined Radio (SDR) has demonstrated its immense capability in implementation and testing of wireless networks. The strength and flexibility that SDR provides also comes with innate challenges in building a working system from the ground up. This project has thus far focused on implementing and thoroughly understanding the intricacies of a wireless network.

FRAME DETECTION

The wireless network has been designed to detect frames of data at the receiver through the auto correlation of short and long training sequences in the frame header.

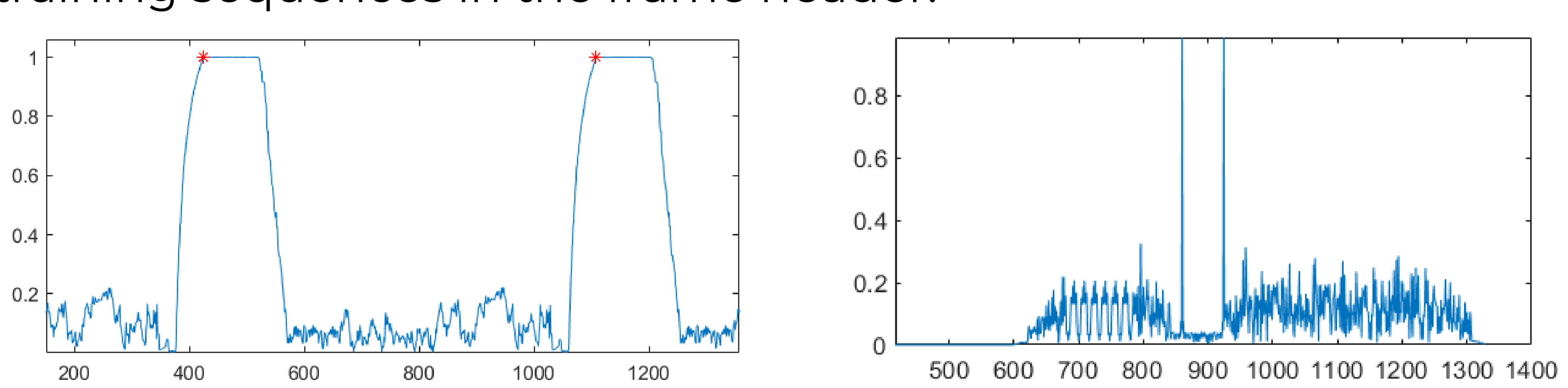

Fig1. Auto correlation using frame detection code, (Left), and cross correlation with the known training sequence for symbol alignment (Right)

Exact symbol alignment can be achieved by cross correlating the received signal with the known long training sequence, matching the first peak to the start of the first OFDM symbol in the long preamble. Processing refinements are then necessary to correctly decode the received signal, which presented the largest difficulties due to certain hardware limitations.

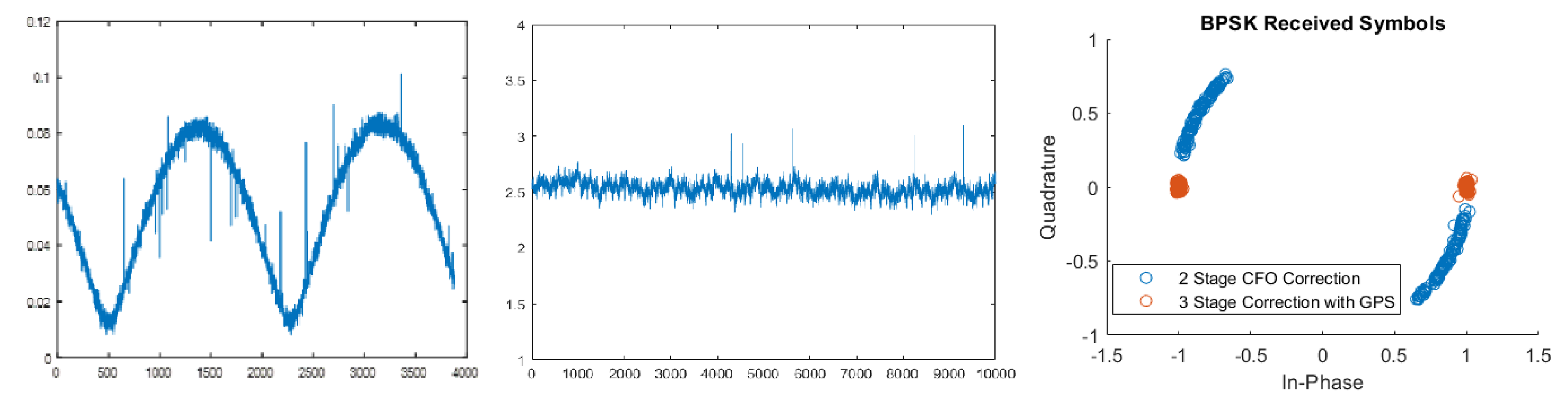

Fig2. Phase of the received signal with standard CFO compensation, then with GPS and third stage correction, right is a constellation of a BPSK transmission for both processing methods.

CARRIER FREQUENCY OFFSET (CFO)

Initials obstacles revolved around discrepancies in the SDR kits. This includes a mismatch in local oscillators which control the signal's carrier frequency, creating a progressive phase in the received signal that needs to be corrected. Standard compensation methods include coarse and fine phase corrections based on the short and long training sequences; however, such methodology leaves a residual phase in the signal.

To correct the issue, a GPS reference clock was added to the system, and a third stage of CFO estimation and compensation was designed. Further trials led to parameter optimization, such as tuning the LNA gain in the receive chain to achieve maximum SNR. These tests identified hardware setups that allowed sampling frequencies up to 10 MHz while maintaining signal integrity.

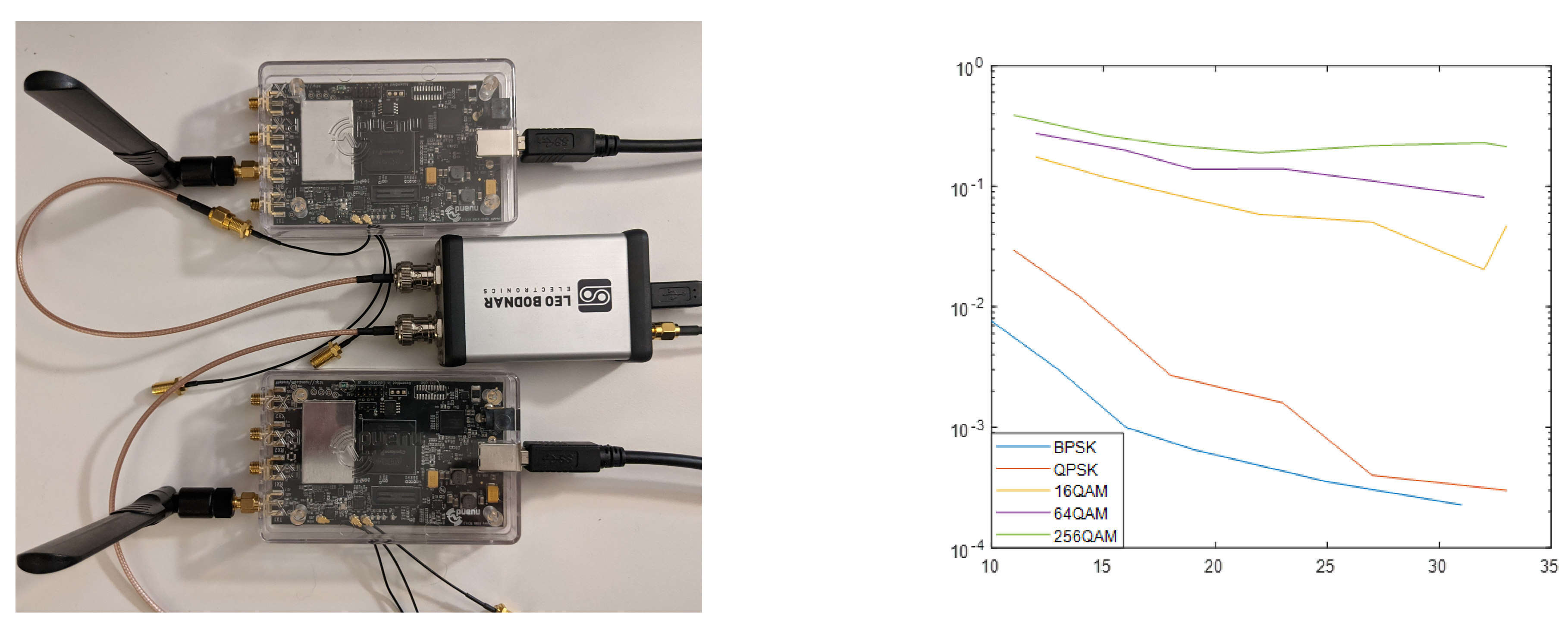

Fig3. SISO system setup for network testing and design (Left). Achieved BER vs SNR for various modulation methods (Right).

POLYPHASE SYNCHRONIZATION

Upsampling and filtering of the preprocessed signal creates phase shifted copies of the filtered transmission. To correctly retrieve the downsampled signal at the receiver, the transmission must first be passed through a matched filter at the correct sampling point. This synchronization is achieved through use of a polyphase filterbank, which identifies the correct sampling point by looking for a zero differential signal output using phase shifted versions of the filter.

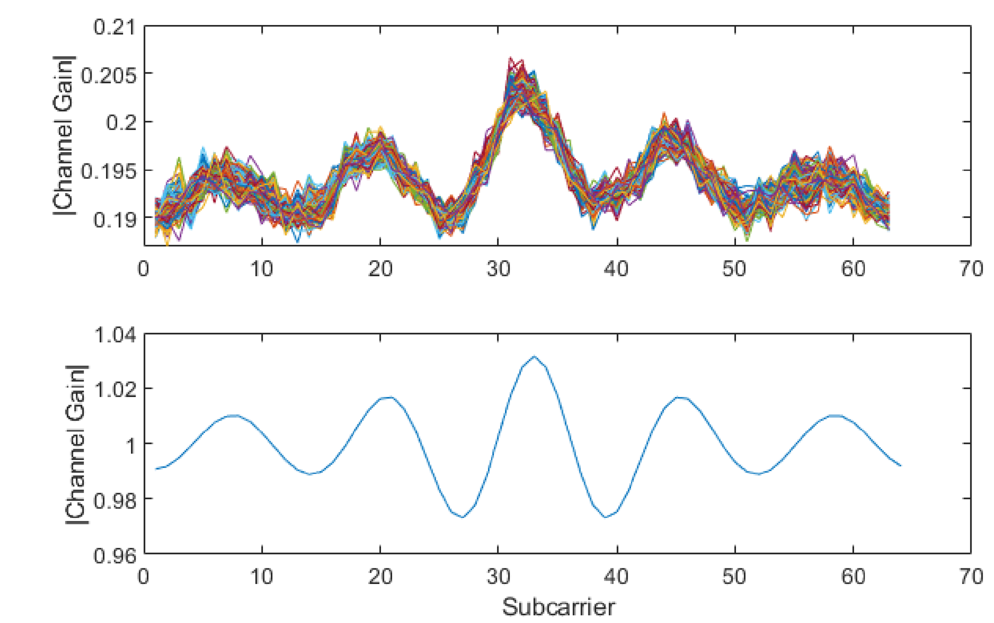

Fig4. Recovery of the "ideal" channel. Channel of a real transmission after processing (Top) vs theoretical channel (Bottom).

NEXT STEPS

Design and train a neural network to process and relay data from one receiver to another based on known channel data, reducing burden on the base station.

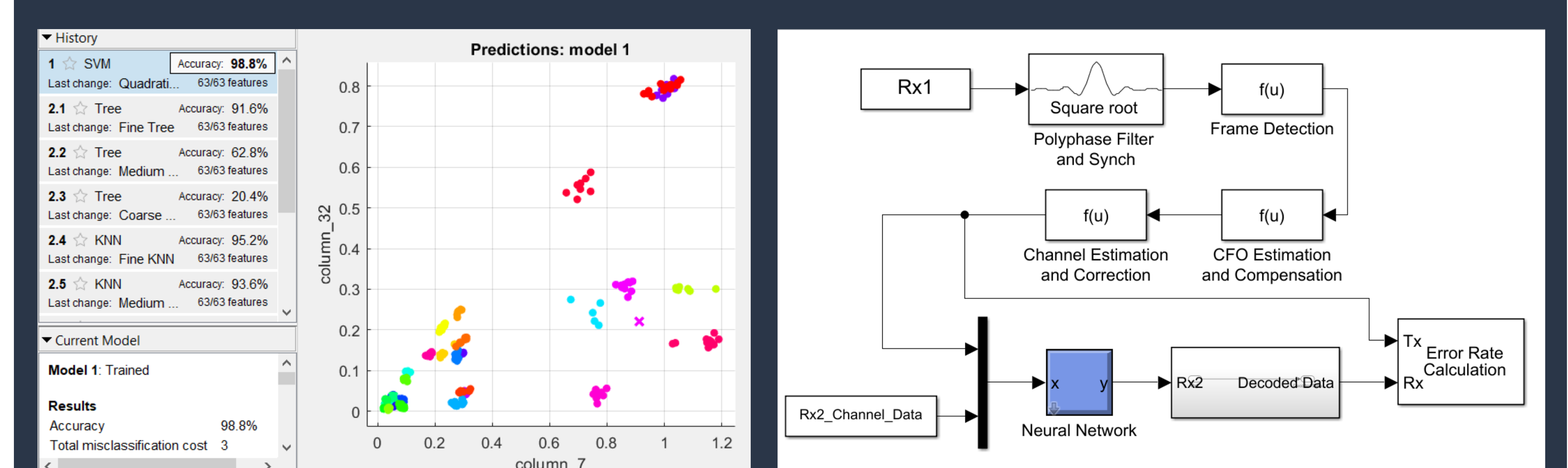

Fig5. Initial channel classification attempt for multiple receiver locations using various modeling methods (Left). Flow graph of received signal processing from Rx 1 through data relay to Rx 2 (Right).

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Ira A. Fulton Schools of Engineering
Arizona State University