WINLAB | Wireless Information Network Laboratory

Using FPGAs for Spectrum Sensing and Modulation Recognition

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Introduction

The past 20 years has seen an explosion of radio communications, from cell-phones, to WiFi and bluetooth. Using software defined radios to record these various devices, one can use this data as a set of neural nets to classify these types of devices based on their RF signal.

Objectives/Applications

Objectives:

★ Use machine learning to recognize different wireless devices
★ Record IQ samples from various wireless devices by using SDRs
★ Classify device based on its modulation scheme

Applications:

- Spectrum Sensing
- Classify the wireless devices
- Network Security Monitoring

Random Number Generator

- Create a Linear Feedback Shift Register to generate pseudo-random bit sequences.
- Each signal is represented by its own sequence.
- Use matched filter to look for certain patterns in the sequences to help determine the signals.

Experiment

Goal: Mimic WiFi 802.11n transmissions in a (mostly) controlled environment to be used later as training data for a modulation recognition neural network.

Data Details

Purpose	Resource
Physical transmission / reception	USRP X310, B210
WiFi IQ Sample Generation	MATLAB Wireless Toolbox
Transmit / Receive IQ samples	UHD Sample Scripts
Experiment Management	OEDL
Experiment Location	ORBIT Grid

Constants

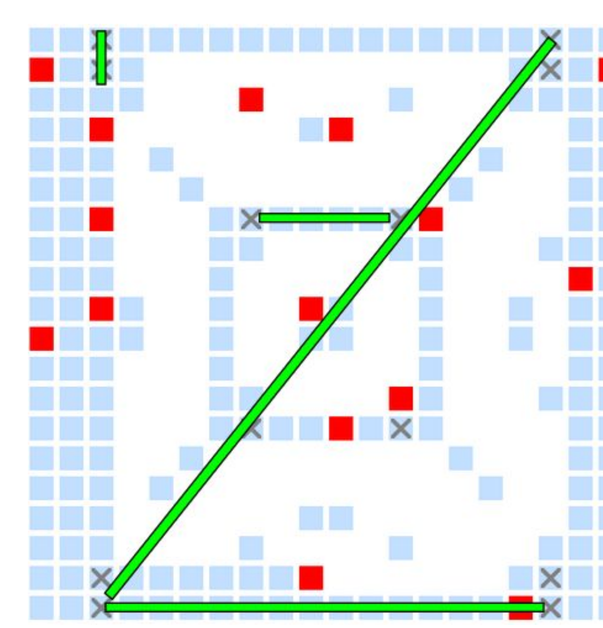
Transmitter Bandwidth	20 Mhz
Receiver Sampling Rate	40 MSps
Input/Output Binary File Format	int16
Packet Payload Size	1500 Bytes
Samples	40M, 80M (when permitted) *

Variables

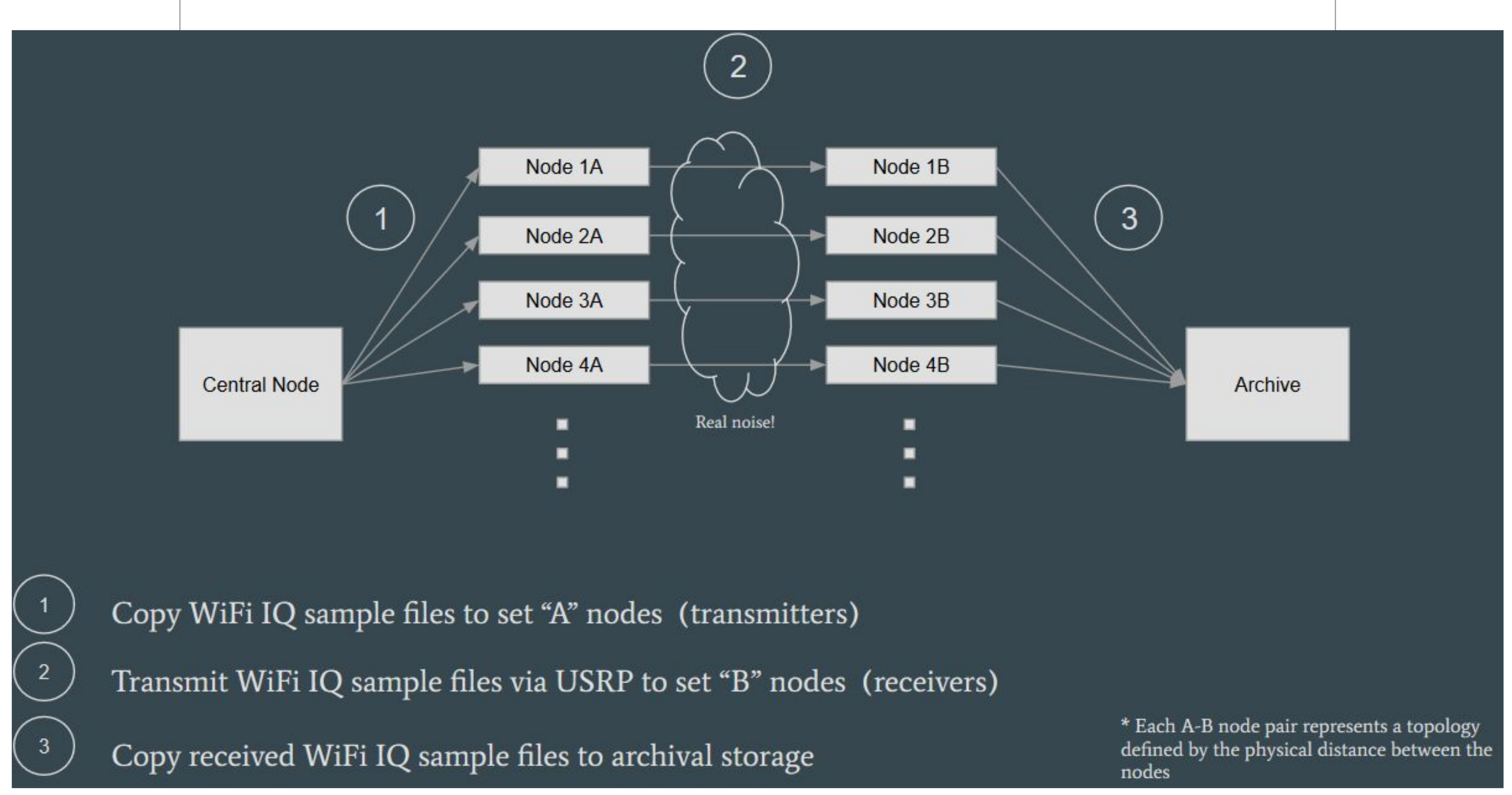
Distance (ft)	3, 15, 45, 72
Frequency (Mhz)	2412, 2437, 2462, 5180, 5240, 5745, 5825
Modulation and Coding Scheme (MCS)	0, 1, 2, 3, 4, 5, 6, 7

Experiment Layout

Each square with an "X" marks a node that we are using. Each green line represents a distance between nodes, the shortest being 3ft, largest 72ft.



Data Collection Flow



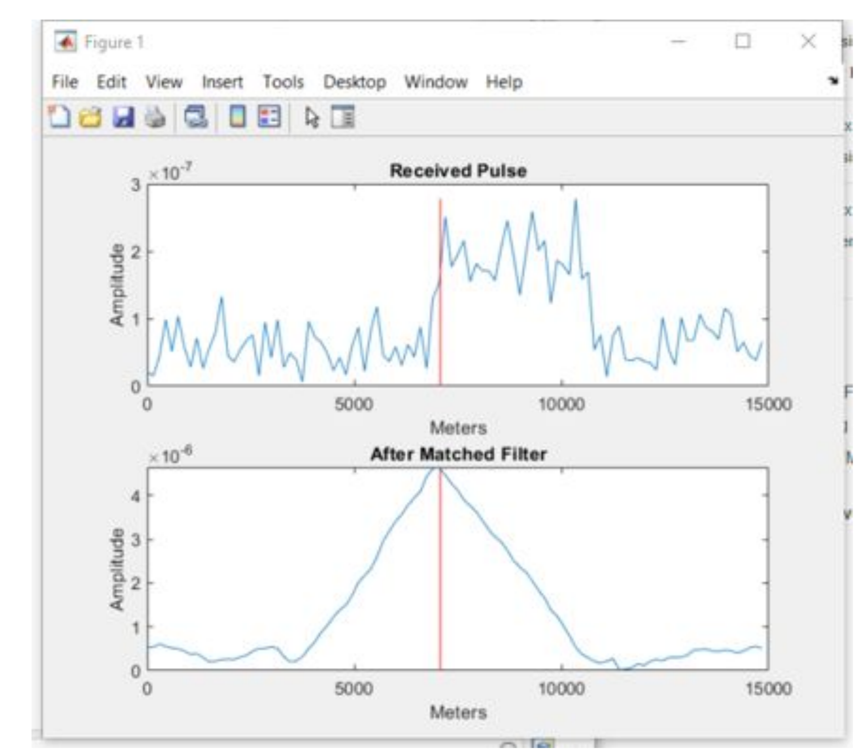
Matched Filters

What It Is:

★ Detect if a "template" signal is present in a noisy, unknown signal (Do they match?)
★ Used to determine if the unknown signal follows a particular modulation scheme

What It Is To Us:

★ Neural Network Based Modulation requires very little a priori information
★ Matched Filters require a priori information and is used for signals we have decent knowledge of
★ Want to make sure performance of neural network is at least comparable to that of matched filter for signals we know some information about



Future Plans

Use Matched Filter to ID Modulation Schemes

- Get random data using number generator
- Create 8-bit sequence + modulation to use for matched filter
- Use matched filter to find hits with the random data

Use Matched Filter in Conjunction with Neural Net Data and FPGA to Classify Devices

- Compare Effectiveness of Matched Filters versus Machine Learning in Matlab
- Transition to Making Matched Filter in Go in order to Utilize Goroutines for Faster Programming
- Compile Go Filter into Verilog using argo2verilog compiler to be used with FPGA in order to detect RF signatures from various devices

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