Directional Signal Transmission in Energy Efficient Wireless Data Communications

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Introduction

- Poor energy efficiency due to omni-directional signal transmission
- To improve the performance of the wireless communication system, we explore directional signal transmission using multiple antennas, a more effective alternative.
- We investigate the wireless channel estimation in precoding and study the effect of different receiver movements on the accuracy of beam steering, using Universal Software Radio Peripheral (USRP) E310 and GNU Radio applying Principal Component Analysis (PCA) method.
- We use a motion sensor to record the actual movement of the receiver and then demonstrate the effectiveness of our PCA method.

Interference & Energy Saving

(a) Constructive and destructive interference

USRP E310

- The USRP E310 offers a portable stand-alone software defined radio platform designed for field deployment.
- Flexible 2x2 MIMO
- Provides up to 56 MHz of instantaneous bandwidth and spans frequencies from 70 MHz – 6 GHz

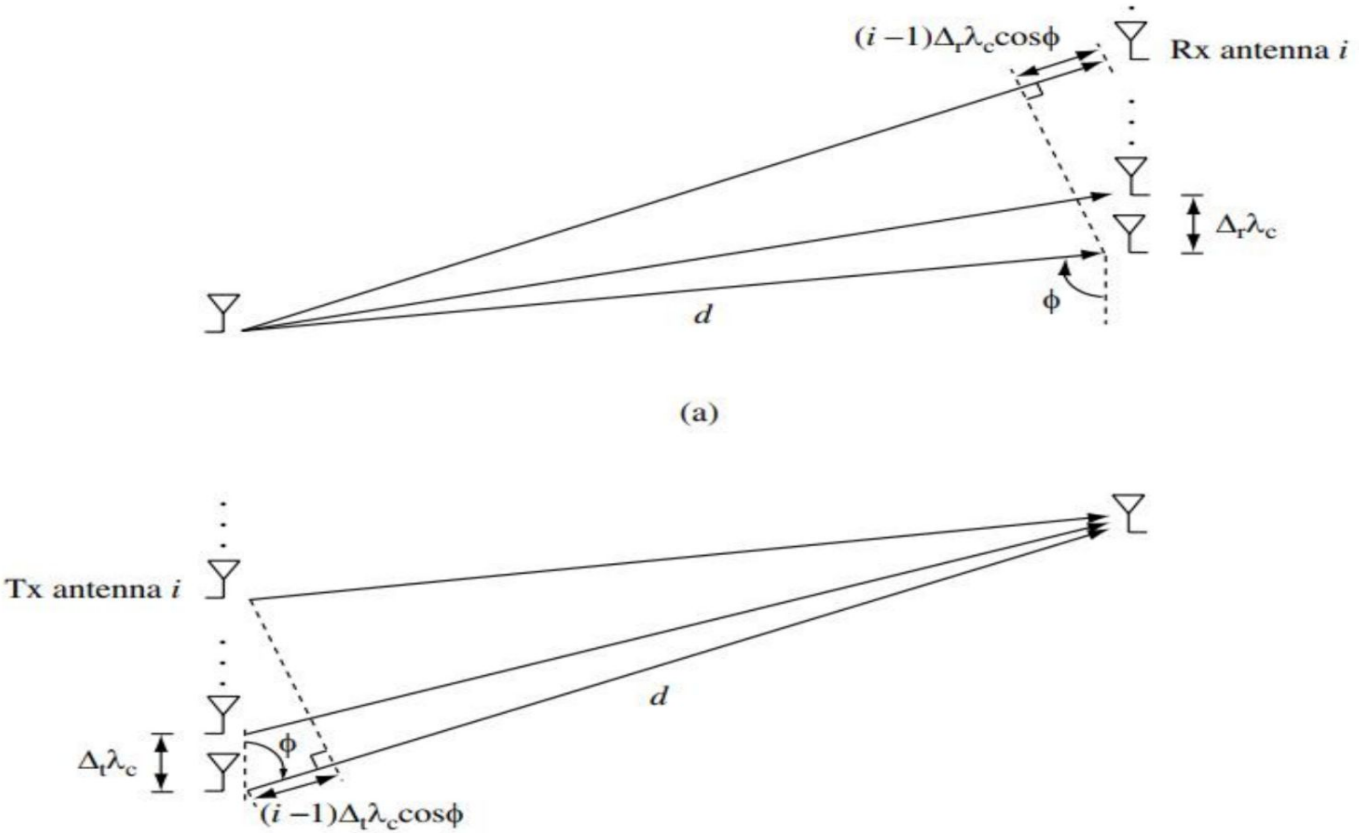
GNURADIO

- GNU Radio is a free & open-source software development toolkit that provides signal processing blocks to implement software radios.
- Use it to write applications to receive and transmit data with radio hardware, or to create entirely simulation-based applications.

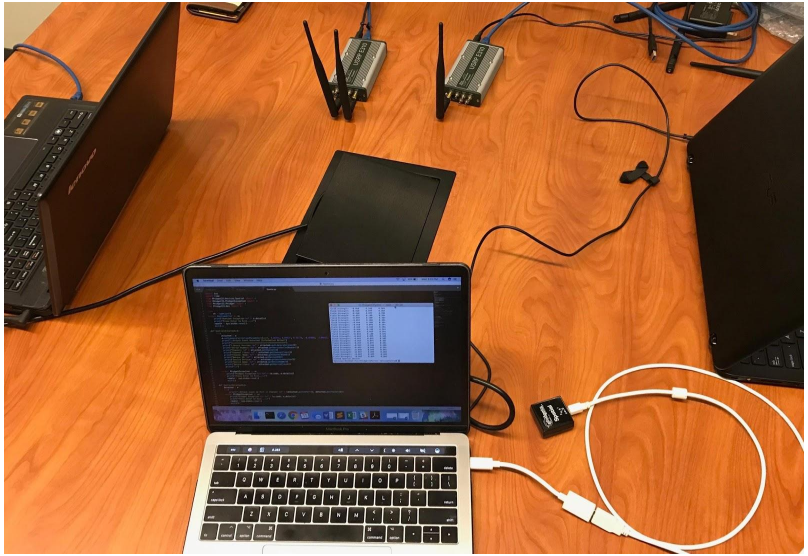
Some Mathematical Concepts

1. Calculating Phase Difference with **Principal Component Analysis**
2. **Angle of arrival (AoA)** measurement is a method for determining the direction of propagation of a radio-frequency wave incident on an antenna array or determined from maximum signal strength during antenna rotation.

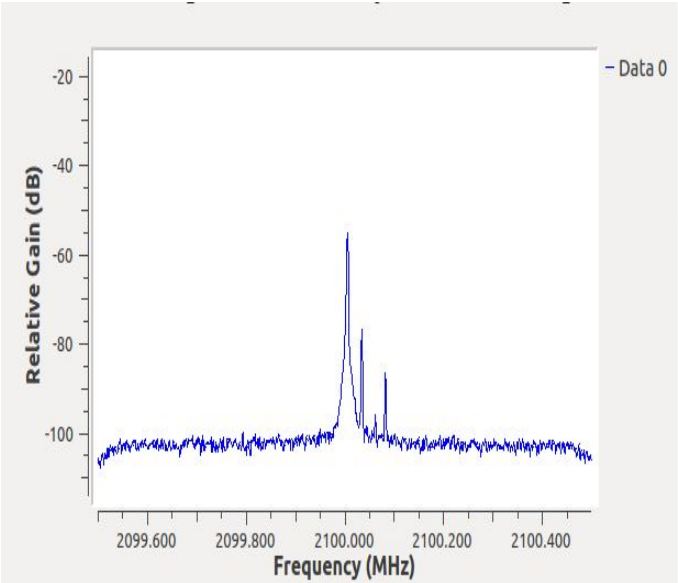
Angle of Arrival Detection Model

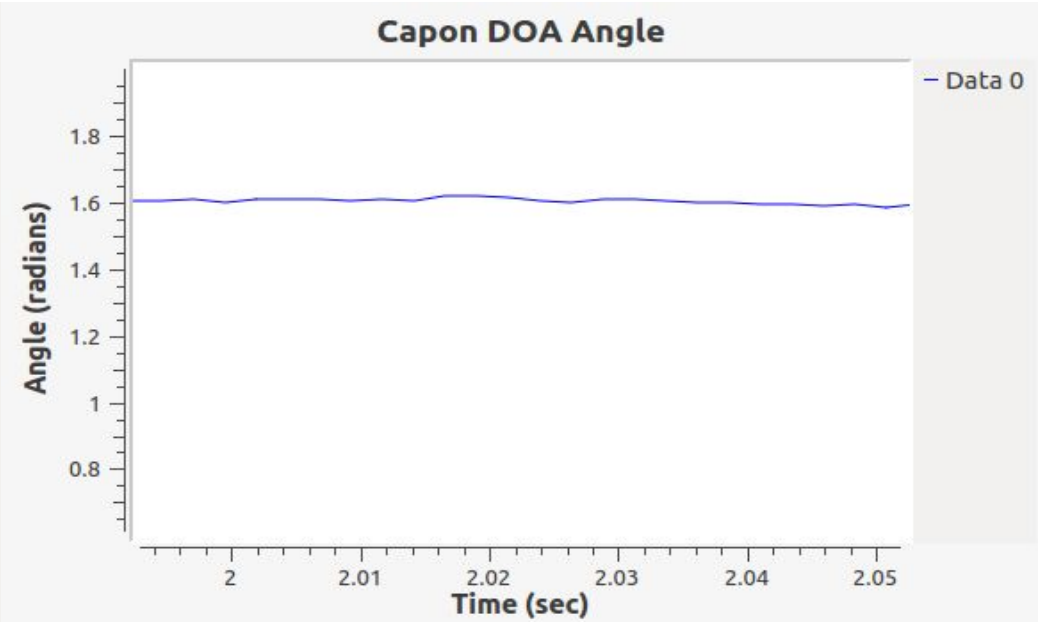


Experiment Setup



Results


Data 0
-20
-40
-60
-80
-100
Relative Gain (dB)
2099.600
2099.800
2100.000
2100.200
2100.400
Frequency (MHz)


Capon DOA Angle
Data 0
1.8
1.6
1.4
1.2
1
0.8
Angle (radians)
2
2.01
2.02
2.03
2.04
2.05
Time (sec)


Frequency (Hz)
2100000000

Conclusion

- We gained knowledge on the system architecture of wireless communication systems and the mechanism of directional signal transmission
- We developed both software and hardware skills to automate the data communications procedure and set up both hardware and software components needed to conduct on-site testing and data analysis
- The final phase will include analysis of the experimental results and comparing them with traditional signal transmission. We hope to reveal the advantages and challenges in implementing directional signal transmission.