RUTGERS
WINLAB | Wireless Information Network Laboratory

Multistatic RFID interrogation & localization with Cosmos/Orbit

Dimitrios Angelou (UG) | Advisor: Bletsas Aggelos - 2024

1 Overview

Commercial RFID tags and readers are widely used in industry for inventory management, object tracking, access control, and personnel identification. They are ideal for such applications due to their low cost, ease of attachment, and versatility.

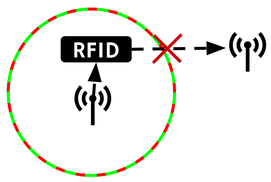
Current RFID reader solutions are proprietary and monostatic, limiting researchers' ability to control low-level communication between the tag and the reader, perform channel state estimation and achieve high distance communication

This project aims:

1. To provide researchers with a platform to experiment with batteryless RFID technology.
2. Demonstrate tag localization using a multistatic topology.
3. Explore methods to mitigate the CFO/CPO problem.

2 Why batteryless & multistatic?

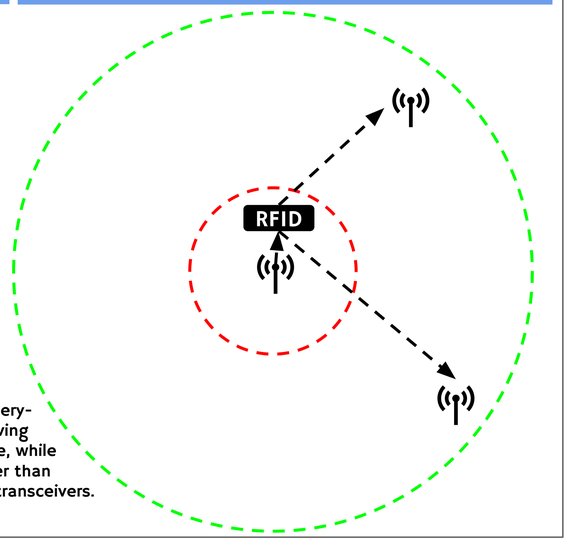
MONOSTATIC



Batteryless RFID tags are greatly limited by their activation range. They need to be close to the transmission antenna to be powered.

Active, battery powered RFID tags are much more expensive, bulky and difficult to attach to objects.

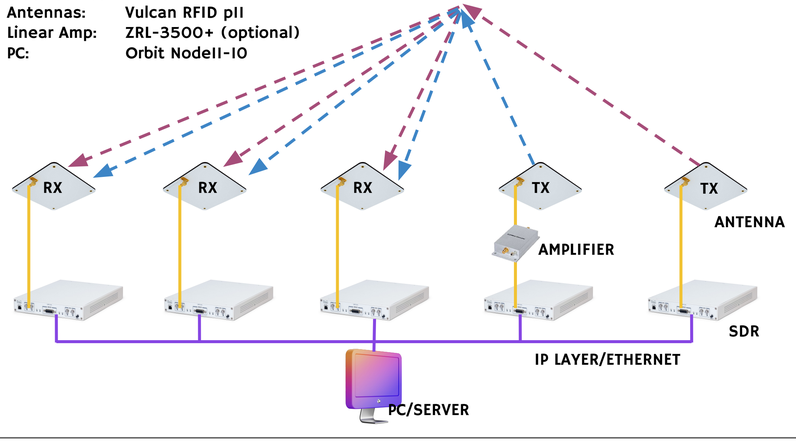
MULTISTATIC



Multistatic topologies exploiting batteryless tags solve both problems, achieving a 10-fold increase in reading distance, while keeping the cost of deployment lower than monostatic solutions using multiple transceivers.

3 Setup

SDRs: USRP x310
Clock source: Octoclock
Antennas: Vulcan RFID p11
Linear Amp: ZRL-3500+ (optional)
PC: Orbit Node11-10



4 Interrogating using USRPs and GNURadio

A series of GNURadio OOT modules were created that provide a scalable, performant, real time, modular solution for working with USRPs and Gen2 RFID tags.

usrp_transmitter:

Generates the appropriate query, and acknowledgement bits for communicating with the tags.

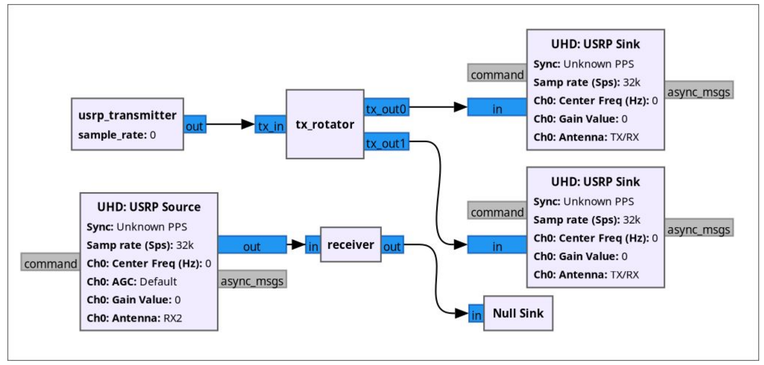
tx_rotator:

Allows for multiple transmitters to work in round-robbin fashion.

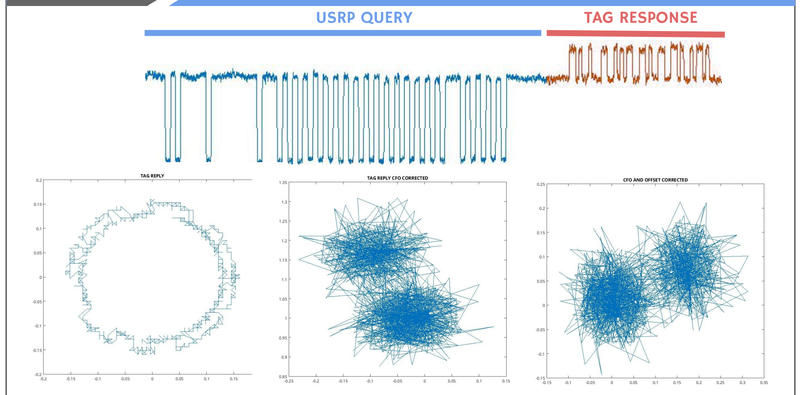
receiver:

Provides real time non-coherent tag transmission detection and phase extraction

All these modules can communicate with a central server providing real time updates.



5 Detection/Phase extraction CFO cancellation



Detection:

Cross-correlate the amplitude of the signal with the known preamble of the Gen2 protocol.

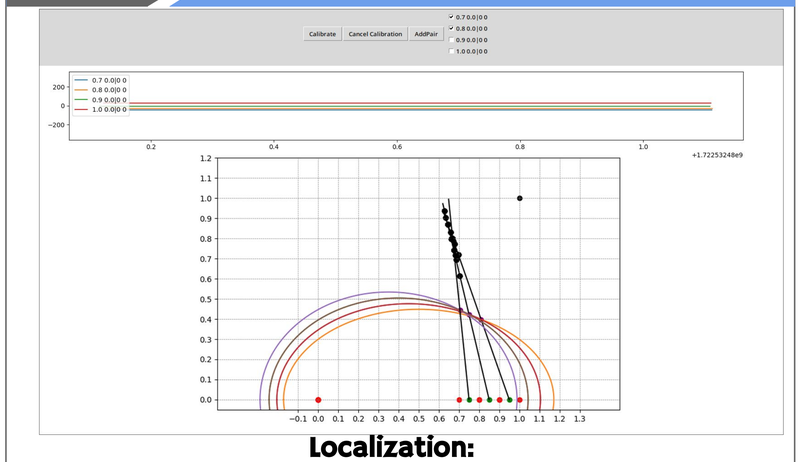
Phase Extraction:

Capture the phase difference between the two states during the tag response

CFO cancellation:

Divide the samples of the tag response by samples captured during the cw and subtract the average of the absorption state.

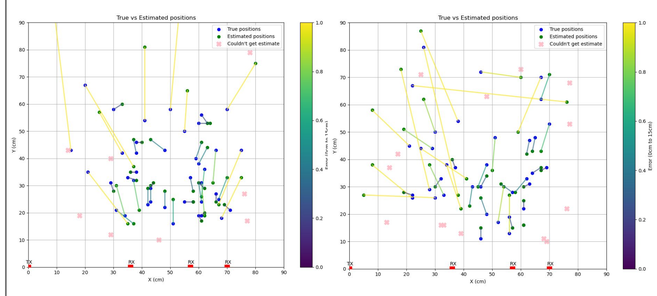
6 Localization and Visualization



Localization:

1. Add receiver pairs
2. Calibrate each pair by placing the tag in the middle, cancelling the CPO.
3. Apply the EllDoA method on each pair.
4. The estimated position is on the intersection of the DoA lines.

7 Results



4 Synchronized USRPs
Sample size: 41

MAE: 7.22cm
RMSE: 14.95cm

2 Synchronized USRPs / 2 RTLSDRs
Sample size: 37

MAE: 8.22cm
RMSE: 13.50cm

USRP DEMO

RTL-SDR DEMO

8 Future work

1. Further experimentation and improvement on CFO cancellation.
2. Automatic CPO cancellation.
3. Full interrogation implementation leading to multiple tag distinction and localization.
4. Extend work to use cheaper SDRs and transmitters.
5. Further improve phase extraction and localization.

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Angelou (UG) | Advisor

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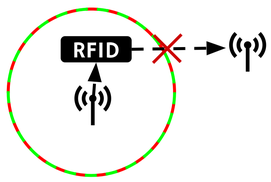

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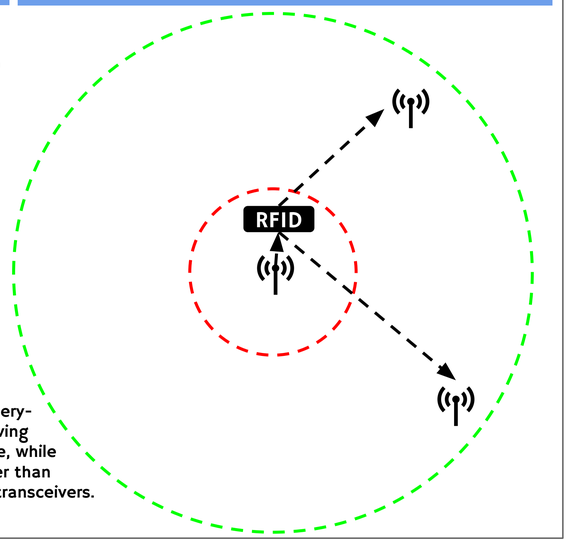

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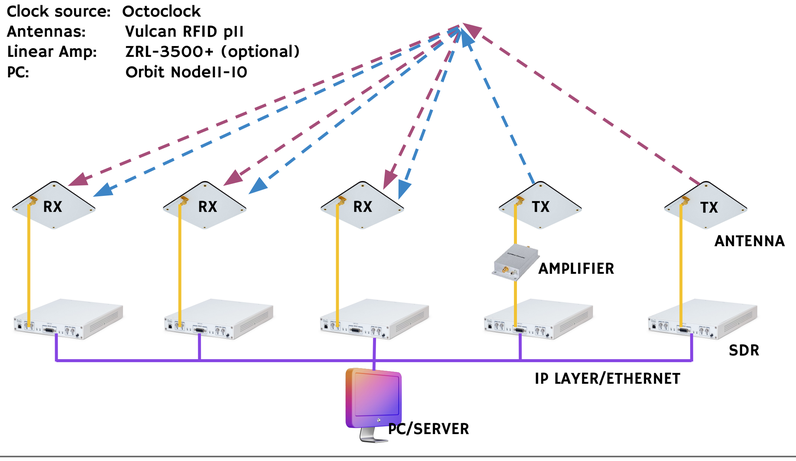

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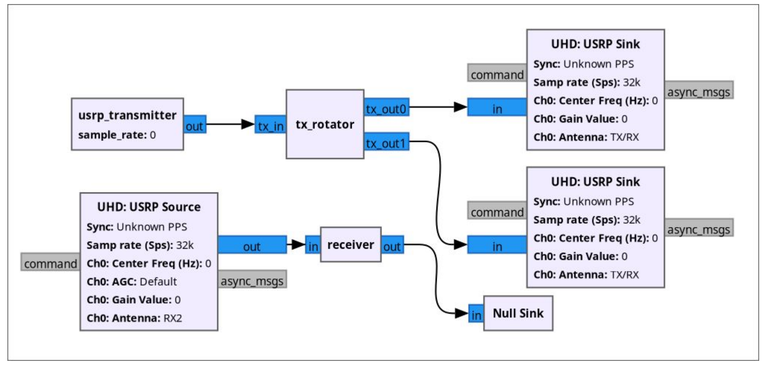

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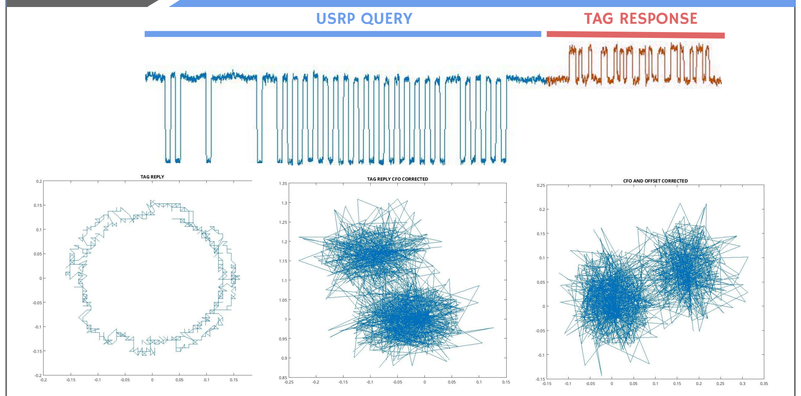

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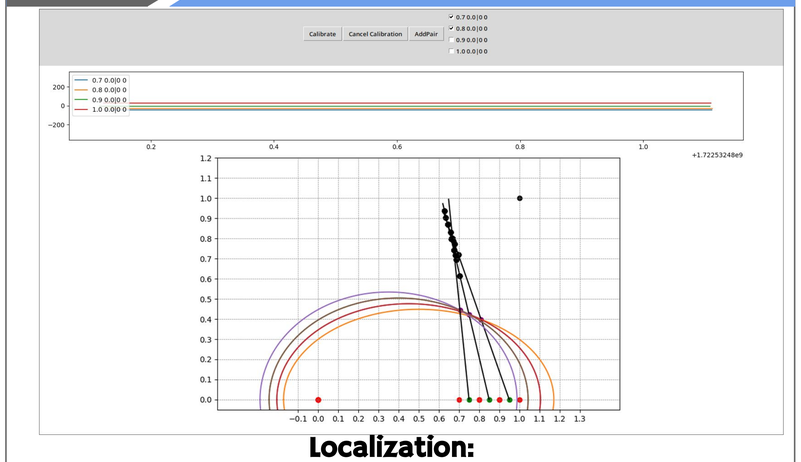

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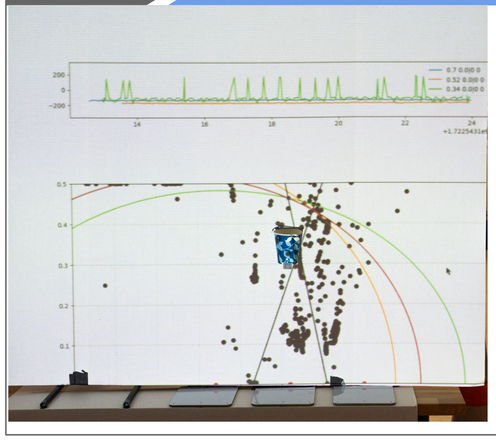
7 Demo



A live demonstration was setup with a projection system on a white board and a tag glued on a sticky cup.

Participants could move the cup to arbitrary positions and observer the algorithm localize the tag in real time.

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