Improving LPWAN Performance using Directional Antennas

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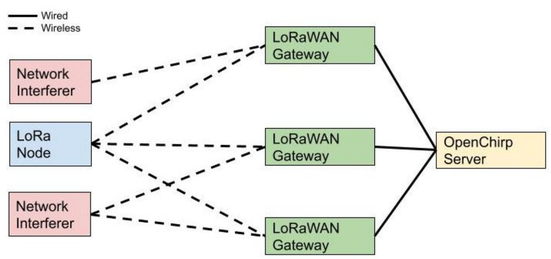
Background and Goals

- Low-Power Wide-Area Networks (LPWANs), such as LoRaWAN, are a popular form of wireless networks for IoT
  - Provides large areas of coverage, long battery life, low cost
  - However, poor network capacity and high interference between clients are significant problems
- Directional antennas are a potential solution
  - Utilizing nulling to focus a node's radiation pattern in specific directions (i.e. toward a gateway)
  - Hoping for improvements in coverage and interference via beam steering for nodes (compared to omnidirectional patterns)



LoRaWAN network architecture. Interferers are not necessarily malicious, but still affect a LoRa node's connection with gateways.

Through nulling, interference between nodes in the network can be improved.

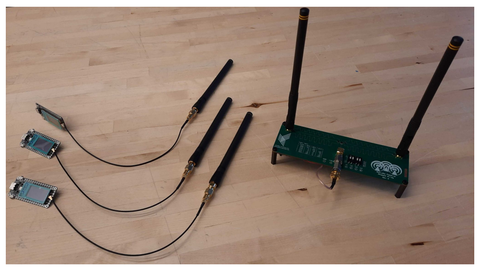
Implementation

- Starter firmware, server code, and hardware design provided by Dr. Artur Balanuta of the WiSE Lab from his NulLoRa paper
  - C++ code running on Heltic CubeCell MCU
  - Server written in Python, hosted using OpenChirp (via ChirpStack)
  - Four LoRaWAN gateways available on-campus for access
- A node cycles through its nulling patterns, tracking which gives best signal
- Upon cycling through patterns, node chooses the best nulling pattern available (or just one of two omnidirectional patterns)
- Server can notify node if signal falls below threshold, then chooses new pattern

Results

- Able to choose between nulling and antenna diversity (i.e. using one of the two omnidirectional patterns)
  - Chooses antenna diversity when interference with other nodes is not a significant factor in performance
  - Chooses nulling if more precise beam steering is needed
  - Cycling methodology works to select the best nulling pattern given interference in current environment
- As more nodes are added to the network, nulling becomes a better choice to avoid interference

LoRaWAN gateways located around CMU's campus.



The NulLoRa test node, alongside other 915 MHz devices used as interferers for testing.

Lessons Learned

- Working with real hardware can be very challenging
  - Waiting for PCBs and parts to arrive
  - Assembling SMD components by hand
  - Hardware defects and malfunctions impeded more thorough testing
- More specific nulling patterns would be ideal for best coverage and interference
  - Tradeoff with hardware complexity and cost per device
- Devices usually wait long times before retransmitting data, so channel conditions may change substantially (requiring recycling)
- Best approach would also utilize network load feedback to select nulling patterns
  - Would need hundreds/thousands of clients to test in the field, so unfortunately unfeasible for this project's scope

18-843: Mobile and Pervasive Computing, Fall 2022
Mentored by Professor Anthony Rowe, Professor Asim Smailagic, Department of Electrical and Computer Engineering.
Special thanks to Dr. Artur Balanuta (ECE PhD, '22) for advising us on our research throughout the semester.

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