Optimization of Distributed Phased Arrays

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Large phased-arrays, ubiquitous for wireless communication, become expensive and complex as the number of nodes increase. With a single oscillator source for an entire array, current phased array (PA) systems are limited by rigid hardware, thereby curbing flexibility and needing large sizes for greater power. To mitigate this problem, this project investigates a distributed PA system using several software-defined radio (SDR) subsystems. The project contains of three parts: deriving new equations to mathematically optimize the coherency of each subsystem, simulating the system in MATLAB, and creating a physical distributed PA system prototype using SDRs as the nodes. To achieve coherency between each node, original MATLAB programs were written to calibrate each radio, determining phase offsets and frequency adjustments for each node. In comparing the calculated signal distances to the actual distance, the error was less than 3% for each pair of antennas. Using chi-squared analysis, the calculated distances match the actual distance with 99% confidence. This calibration data was used for a proof of concept to ensure the mathematical model worked as expected. The prototype consisted of three radios, each with its own phased array subsystem. With the newly derived calibration equations, the final wave had a power of over 6dB, or over 4 times greater than if summing each of the three individual waves. By using SDRs, this project successfully created a flexible system, unlike rigid hardware-based PAs. Such systems grow linearly in cost, whereas current PA systems grow exponentially in cost. Ultimately, distributed systems have 5 main benefits: enhanced signal gain, increased reliability, scalability, adaptability, and greater spatial diversity.

Awards Won:

Central Intelligence Agency: First Award: $1000 award