CALIFORNIA SCIENCE & ENGINEERING FAIR
2019 PROJECT SUMMARY

Name(s)

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Project Number

S1001

Project Title

Frontiers of 5G: Sparse Adaptive Battery-less Ambient Backscatter Communication Networks

Abstract

Objectives

This research project explores the interconnected schemes of ultra-low power ambient backscatter to function as the basis of the next generation of telecommunications technology integration, namely, globalizing Internet of Things (IoT) networks in next-generation 5G networks . However, current telecommunication schemes suffer from connectivity and complexity issues as a result of these highly-overloaded, highly connected networks. Because of this, a novel network structure is developed to facilitate the communication of high-user battery-less ambient backscatter devices. A physical and link layer network structure is devised with the key objectives of minimizing power backscatter-device power consumption and Bit Error Rate (BER) while maximizing network throughput and connectivity among a large population of backscatter devices. This network was then evaluated for accuracy by Monte Carlo simulation of Bit Error Rate optimizing parameters of the network structure compared to current schemes of telecommunications. Finally a theoretical and experimental investigation of this backscatter system as battery-less implant devices in an signal-constrained environment to enable implant longevity without the risks and expense of traditional battery-implants.

Methods

A novel implementation of this signal network was developed using MATLAB and bash/packet sniffer scripts on Raspberry Pi computers integrated with a Software-Defined Radio. We also devise open-form theoretical and Monte Carlo simulations of our project using MATLAB. We use Wireshark, a packet sniffing software, to detect incoming packets from a demonstrated receiver to client network pathway (using a wireless AP and a client laptop). Moreover, Fusion 360 was used to design the backscatter tag 3D model (tailored for an implant environment), as well as Autodesk tools to design electrical circuits and diagrams.

Results

We successfully devise a novel network structure to facilitate resource-constrained, high-user ambient backscatter communication. We simulate various orders of signal modulation relative to changes in Additive White Gaussian Noise (AWGN) replicating real-world conditions to quantify the most effective modulation order for our network. Through cluster analysis of Constellation Plots of various orders, the most effective modulation was deemed the Quadrature Phase Shift Keying Scheme. Overall, thorough Monte Carlo analysis highlights that the novel network had significantly lower Bit Error Rate relative to changes in Signal to Noise Ratio (SNR) compared to traditional time-dividing, code-division multiple access schemes used in state-of-the-art telecommunications schemes. We also quantify the benefits of the network system in

Summary Statement

We develop a new type of communication network for highly connected, battery-less interfaces that is much more effective than state-of-the-art telecommunications methods and effective in specific application environments

Help Received

No direct help was received by any institution or professional scientist and engineer. We met with our science fair advisor to occasionally discuss the broad direction of our research.