Poster: Backscatter Communication for Wireless Robotic Materials

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1 Introduction

Wireless robotic materials [1] are composite materials that programmatically alter their properties such as shape or color in response to external stimuli or commands. Ideally, communication devices for robotic materials would operate without batteries on harvested energy from their environment.

A new class of battery-free communication devices combine, backscatter communication techniques to transmit and receive standard wireless protocols [2, 3]. We refer to this combination as carrier-assisted transceivers. This new communications paradigm is ideal for robotic materials due to its ability to operate on small amounts of energy that can be harvested from the environment. The need for an external unmodulated carrier and the relatively short communication range, however, introduce unprecedented challenges. We employ analytical models to study the feasibility of employing carrier-assisted communications to relay messages within a robotic material in different configurations and network densities.

Our goal is to reduce the necessary output power of the carrier generator which is of great importance to reduce, e.g., radiation exposure in vulnerable groups and to reduce power consumption. Our contribution is that we introduce the suitability of carrier-assisted communications to robotics materials. We show that multi-hop relays within the material can reduce the necessary carrier output power. We demonstrate a further reduction of carrier output power with multiple carrier generators.

2 Evaluation

We base our analysis on the assumption that the signal power at the receiver P_r must overcome the sensitivity threshold S_{th} of the receiver for successful decoding of the data ($P_r > S_{th}$). Substituting the Radar Range equation into the condition, we obtain the following equation for the minimum required carrier output power:

$$P_t > \frac{\sqrt{C}}{G_t G_b G_r \sqrt{\alpha}\frac{|\Delta\Gamma|}{2}} \frac{4\pi R_1}{\lambda} \frac{4\pi R_2}{\lambda} \frac{4\pi R_3}{\lambda} \qquad (1)$$

Setup. Figure 1(a) represents the setup for multi-hop scenario with a single carrier generator. We evaluate the minimum carrier generator power needed for the reception using Equation 1 and the dependency of the minimum necessary carrier generator power with the network density, achieved by altering the number k.

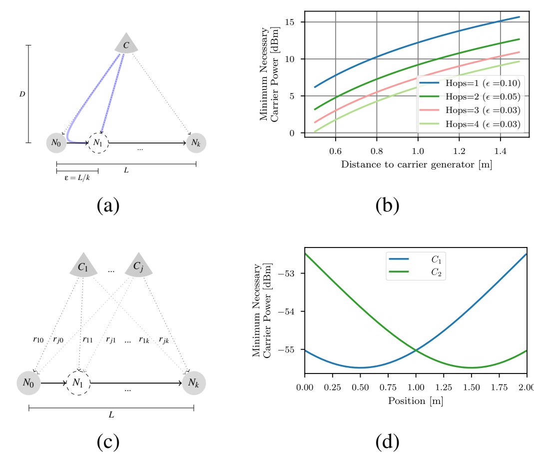

Figure 1. *Evaluation Setup and Result for Fixed length L*

Result. Figure 1(b) shows the results. The necessary carrier output power decreases with the distance between transmitter and receiver (ε) as expected. Increasing the number of hops decreases the distance between consecutive nodes, offsetting the necessary carrier output power. This implies that we can relax the requirements on the carrier's output power by increasing the number of hops.

Setup. Figure 1(c) shows the setup for multiple carrier generators. The distances from the carrier generators to the carrier-assisted devices is much larger than the separation among them ($r_{10} \ldots r_{jk} \gg \varepsilon = L/k$).

Result. Figure 1(d) depicts the result of the experiment. The further the distance, the higher the power required from any individual carrier generator. After a threshold distance a neighboring carrier generation can take over in assisting to relay a message. This implies that delegating the task of carrier generation to multiple nodes helps reduce the minimum power required from any individual carrier generator in the wireless robotic material.

3 References

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