"Drone Relays for Battery-Free Networks"

March 26, 2018

The chosen paper proposes RFly, a system that makes use of drone-mounted relays to extend the range of commercially available RFIDs systems from a few meters to tens of meters. In addition, it also introduces the first full-duplex relay for battery-free networks, and it proposes the first RF-localization algorithm that can operate through a mobile relay.
The aim of this publication is to come up with a solution of passive RFID technology being only reliable at distances of few meters. The paper specifically focuses on scenarios like retail warehouses in which the tags are buried one under the other, usually not even in the line of sight, hence, making it even more difficult to perform long-distance measurements. The relay is designed to satisfy three key properties: it must be bidirectional full-duplex to enable backscatter communication, it has to preserve phase and timing to enable localization, and it must be compact to be able to mount the PCB on any commercial low-range drone.
To overcome these challenges, RFly proposes a mirrored architecture built on a 10 x 7.5 cm PCB that comprises two major components. The first performs analog self-interference cancellation to enable bidirectionally full-duplex communication, and the second one compensates for the offset of the first stage, thus, preserving the phase required for the localization algorithm. Additionally, the amplification of the signal on the relay is done using variable gain amplifiers to ensure the quality of the communication link. RFly localization algorithm builds on synthetic aperture radar (SAR). As the drone flies, the relay captures a series of RFID responses from different locations along the drone's trajectory and treats these measurements as an antenna array. Afterward, it localizes the RFID by applying antenna array equations to these measurements. Unlike other SAR implementations, RFly deals with phase entanglement, that is, phase measurements not coming directly from the RFID, rather, two half-links, one coming from reader to relay and another between relay and RFID. As a second challenge, RFly deals with the multipath environment since the packets do not only arrive in line of sight. Rather, they bounce off of different objects in the environment. Finally, the paper presents a prototype implementation and evaluation, where the key properties are satisfied and the Reader-Tag range is proven to be extended to 50 meters compared to the few meters obtainable with traditional Reader-Tag implementations. Additionally, an error of around 18cm is shown to be obtained using the proposed localization algorithm, which is compared to a commercially available Infrared localization system, giving good results. The proposed method seems also energy efficient, using only a small

percentage of the drone's energy (around 3%).
The noticeable drawbacks of the paper are: the lack of an RF-based navigation required for the localization system to work properly without other aids, the focus of the study on the utilization of only one drone and the market limitations in finding an RFID reader with accurate 360 phase measuring capabilities. However, given the backward compatibility, the range improvement, the energy efficiency and the relatively simple implementation we think that the proposed setup can serve as the baseline to future work where these drawbacks can be assessed and even more robust implementations can be proposed.

Paper Reference: http://www.mit.edu/ fadel/papers/RFly-paper.pdf