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Poster Abstract: Multi-Drone Assisted Internet of Things Testbed Based on Bluetooth 5 Communications

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ABSTRACT

In this paper, a multi-hop airborne system is built based on Bluetooth 5 connected autonomous drones to relay real-time data of Internet of Things (IoT). A new lightweight Onboard Bluetooth Transceiver (OBT) is developed for reliable drone-to-drone and drone-to-ground communications. A graphical user interface is presented to monitor real-time flight trajectory of the drones and end-to-end data delivery. Outdoor experiments are conducted in real world to test autonomous flight control of the drones and received signal strength of the OBT communications.

CCS CONCEPTS

• **Computer systems organization → Embedded and cyber-physical systems**.

KEYWORDS

Autonomous drones, Aerial data relay, System testbed, Experiments

1 INTRODUCTION

Employing autonomous drones as aerial data relays has great potential to improve system connectivity, scalability and infrastructure coverage in Internet of Things (IoT) applications, such as intelligent transportation [7], precision agriculture [4], and disaster management [3]. A drone equipped with wireless radios flies along a predetermined trajectory while relaying data of ground IoT nodes as a data mule in the area of interest [6], thanks to its excellent mobility and maneuverability. The short distance line-of-sight (LoS) communication between the drone and the ground IoT nodes can support high-speed data access and significant channel gain [5].

In this paper, we build a multi-hop airborne relay system for Internet of Things (IoT) based on Bluetooth 5 connected autonomous drones, as shown in Figure 1(a). A new lightweight software defined radio is developed to enable Bluetooth 5 communications for the drones and the ground IoT nodes. The designed Onboard Bluetooth 5 Transceiver (OBT) has a tiny dimension of 36mm x 36mm with a total weight just about 6 g, suitable for bird-size micro drones. Moreover, OBT supports multiple concurrent connections and continuously adapts carrier frequency for anti-jamming capabilities, where the receiver recombines the received signals in the order specified by the transmitter.

2 SYSTEM OVERVIEW

The autonomous drone contains two inter-connected modules, i.e., autonomous flight control and OBT communications. The autonomous flight control is implemented based on an MX400 platform [2]. The drone estimates its current position by synthetically analyzing real-time measurements from onboard sensors, such as accelerometers, Gyro sensors, barometers, and compass sensors. The OBT module supports a maximum data rate of 2 Mbps, which enables high-speed data transmission at the drones and the IoT nodes. In addition, OBT detects and prevents interference with WiFi or LTE by carrying out frequency hopping spread spectrum, where one frequency over 40 channels is selected following a pseudo-random sequence at the rate of 1600 hops per second.

3 FIELD TEST AND PRELIMINARY RESULTS

We conducted outdoor field experiments for testing the autonomous flight control and measuring Received Signal Strength (RSS) of the OBT communications. The sensory data are generated by the source IoT node, and relayed by two autonomous drones, Drone A and Drone B, to the data sink node. The source IoT node and the sink node are obstructed with no LoS communication link. The two drones move independently along the squared trajectory between the source node and the sink node. The transmission of data packets is initialized by the source node. The data packet is transmitted to the first hop, i.e., Drone A. Once the packet is successfully received, Drone A immediately forwards to Drone B, while an acknowledgement packet is sent to the source node so that a new packet can be transmitted by the source node. A graphical user interface, as shown in Figure 1(b), is implemented based on MindCentral software [1] to monitor real-time flight trajectory of the drones and end-to-end data delivery.

Figure 2 shows preliminary experimental results of RSS measurements of the three Bluetooth 5 links, i.e., the source IoT node to Drone A, Drone A to Drone B, and Drone B to the sink node. The RSS is measured on the transmission of the data packet and the acknowledgement packet, which provides both uplink and downlink channel quality. As observed, the uplink and downlink of each bluetooth channel are highly correlated along the flight of the autonomous drones, which reveals similarity of physical-layer interpretation of the airborne Bluetooth 5 communication. This can be potentially used for physical-layer security developments. The experiments in Figure 2 also confirm that the designed OBT for the

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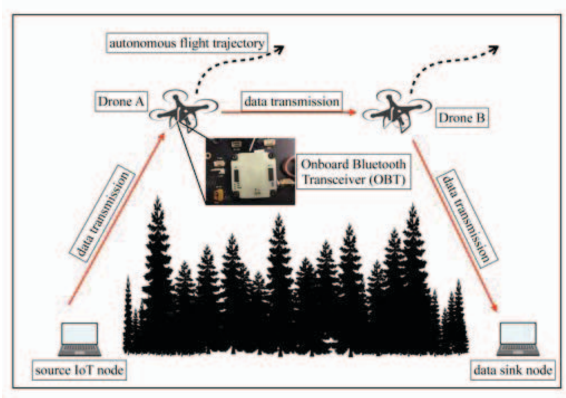

(a) System overview.

(b) Graphical user interface for real-time system monitoring.

Figure 1: System overview and outdoor field experiments.

drones can successfully relay the data for the ground IoT nodes using the Bluetooth 5 connection.

4 CONCLUSIONS

This paper demonstrates a multi-hop relay system for IoT based on the Bluetooth 5 connected autonomous drones. We develop a new lightweight OBT for reliable airborne bluetooth communications. A graphical user interface is presented to monitor the real-time flight trajectory of the autonomous drones and end-to-end data delivery performance. Preliminary RSS measurements on the testbed show high correlation of the uplink and downlink of the airborne bluetooth channel.

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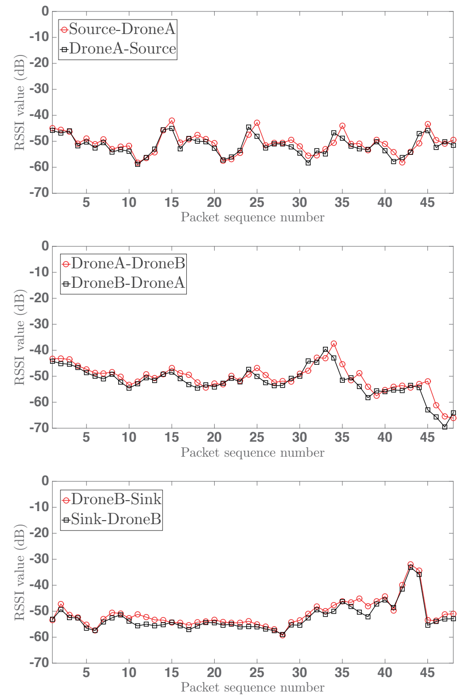

Figure 2: RSS measurements of the airborne channels.

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