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The Design and Implementation of an Intelligent Letter Box

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Design and Implementation of an Intelligent Letter box

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Abstract

A major cost of transportation for the US postal services is collecting mail from blue collection boxes across the country, with their numbers steadily declining over the years, to save on fuel costs. This cost could be significantly curtailed if boxes that contain mail at collection times can be identified. This paper provides a detailed study and implementation of a smart mail detection and alerting system. The system detects if any mail is placed in the blue collection box and sends an alert to the local post office indicating whether the box should or should not be visited.

Keywords

IEEE 802.15.4., Wireless Sensor Networks, ZigBee

I. Introduction

Mail collection boxes are essential to the postal service. They are used to collect mail in the residential area and cities, across the country. In the United States, the largest cost for the postal service is fuel. The USPS reported that the fuel cost of operating its fleet was $182 million in 2016. Most of this fuel consumed collecting mail from the blue collection boxes. The 2016 sustainability report by USPS outlines some of their environmental goals for 2025. The USPS's annual greenhouse gases inventory reports are used for transparency and allows measured progression to their greenhouse gases reduction for 2025. One of the USPS goals for greenhouse gas reduction includes reduction of emission from Postal Service –owned vehicles and facilities. Since 2014, USPS has added 20,000 vehicles to their fleet. The new vehicles have resulted in a decline in progress to the 2025 goal. The primary service of the USPS is letter mail and package processing and delivery, this includes collecting and delivering mail [1]. One of the most time consuming tasks of USPS drivers is collecting mail from letter boxes. Drivers must visit every box in their area. The implementation of smart mailbox systems, could allow for a reduction not only in the emissions made by vehicles, but also in the size of the fleet needed to meet customer service requirements. The ability to distinguish which boxes have mail and which do not, can reduce the amount of time taken collecting mail, the distance traveled by each driver, the fuel consumed by the vehicles, and the emissions that result from diving.

Traditionally, the postal service uses non-smart blue collection boxes, which are simple collection containers without any sensors to indicate quantity of mail. The blue collection boxes are non-smart. This project highlights the importance of wireless sensor networks by providing a detailed study and implementation of smart mail detection and alerting system. The function of this project is detecting mail from a blue collection box and sending this information to a base station. A data analyst or a postal service manager can receive and interoperate the information. Based on the information received, the postal service provider can coordinate the routes for the drivers. This allows for a much more cost efficient collection of mail.

II. System Design

An overview of the design is shown in Fig. 1 where a smart collection box communicates with a base station indicating if there is any mail available in the mailbox. The overall design comprises of hardware and software components as described below.

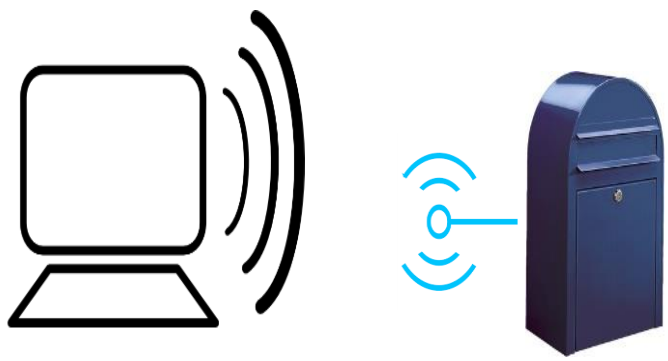

Fig 1 : Overview of Design

A. Hardware

The Wireless Relay Network is established using a network of Xbee pros. The Xbee not only functions as both a transmitter and receiver, but it is perfect for a low power and low cost application. The pro model of the Xbee provides extended range than the standard Xbee. The standard Xbee has a range of 90m, while the Xbee pro has a range of about 1600m and operates at the IEEE 802.15.4 network protocol [6]. The relay network of Xbee pros which is illustrated in Fig. 1., will relay their message until they reach a base station.

The base station acts as a network coordinator and a place where the data can be displayed and analyzed. The base station consists of an Xbee pro that acts as a receiver and a computer with the XCTU application installed on it [5]. When a message is received by the Xbee pro, it is communicated and processed by the computer and the information is displayed to a data analyst at the base station.

The main focus of the sensor nodes is size and efficiency. The sensor node consists of an Arduino Uno, a PIR Sensor, an Xbee module, a lithium ion battery for energy storage and a solar panel. The schematics of the hardware design are illustrated in Fig. 2. The sensor nodes which are illustrated in Fig. 2(a) and Fig. 2(b), respectively, consist of an PIR sensor that can detect motion, a preprogram Arduino Uno that will act as the processing unit, and an Xbee pro which will act as a transmitter and a receiver [4]. When objects move in front of the PIR sensor, the sensor will send a signal to the Arduino Uno [3]. The Arduino has been programed to receive signal from the PIR sensor. The Arduino will count the number of times that the IR sensor sends a signal and transmits it via Xbee to the base station. The sensor node will be powered by a solar power. As seen in Fig2(c), a solar panel, a charge controller, and a battery are connected to the power socket of the Arduino

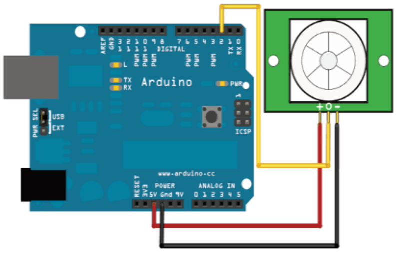

Fig 2(a): Arduino connection to PIR sensor

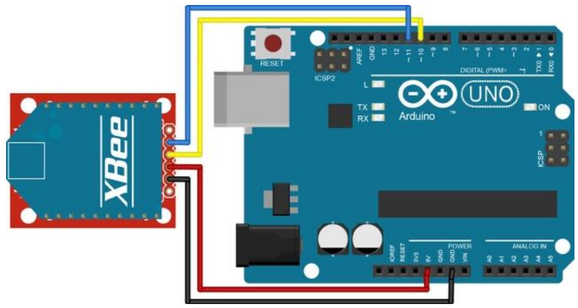

Fig 2(b): Arduino to Xbee connection

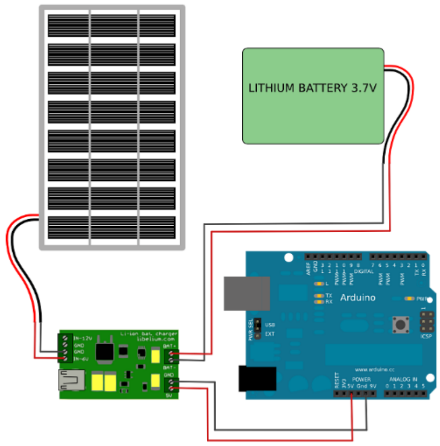

Fig2(c): Arduino connection to solar power and battery

The base station consists of an Xbee Pro antenna and a computer with XCTU software installed. XCTU allows the connection between the base station computer and the sensor nodes. The base station Xbee Pro antenna will receive information from the sensor nodes and send them to the XCTU interface [2]. A data analyst or a postal service manager can receive and interoperate the information. Based on the information received, the postal service provider can coordinate the routes for the drivers. This allows for a much more cost efficient collection of mail.

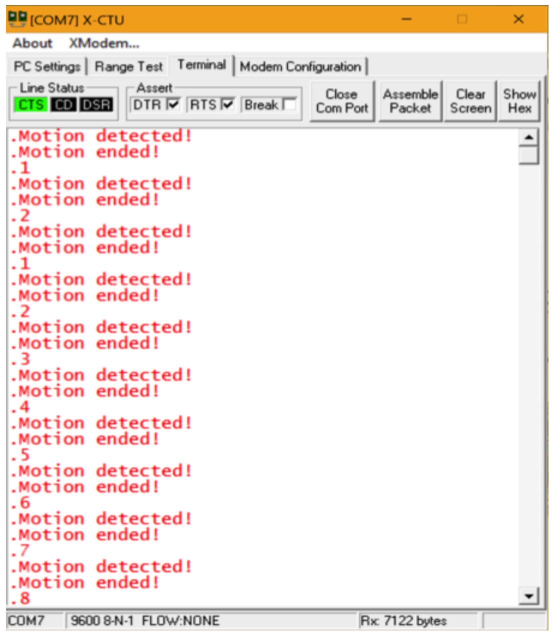

Fig 4. Resulting output on XCTU

B. Software

Programming was done by the use of Arduino IDE. We began by declaring that the input pin for the sensor is pin 2 and declare a serial port for wireless communication. The program checks the value of the input pin and prints "Motion detected" if motion is detected, indicating that mail has been inserted in the blue collection box. For counting purposes, a variable is being incremented each time motion was detected. When motion is no longer detected, a message of "Motion ended!" is printed.

The PIR sensor's signal is processed by the Arduino UNO. The Arduino UNO, which is connected to the XBee shield and the preprogrammed XBee, processes the PIR signal and generates an output of "motion detected" upon receiving the signal and "motion ended" at the end of the signal. At the end of each signal, the detection of motion is saved in a variable named *tot*. The XBee sends this out to its preprogramed receiver at the base station. The base station consists of a receiver XBee which is connected to the explorer which allows a connection to a computer. The received message can be viewed with XCTU software on the computer.

III. Conclusions

In this paper, we presented the design of an intelligent letter box. The system detects if any mail is placed in the blue collection box and sends an alert to the local post office indicating whether the box should or should not be visited by a USPS driver, hence reducing the use of fuel and reduction of greenhouse gas emissions.

IV. References

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