HomeGuard

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Abstract

HomeGuard is an IoT project intended to help secure indoor spaces (apartments, houses, cashboxes). It will monitor an entrance or multiple entrances depending on the configuration, detect motion inside the guarded area and notify the owner in cases of a break-in or an unauthorized entry when they are not inside.

Introduction

Overview

IoT market offers a wide variety of smart home devices like surveillance cameras, locks and home security systems, heating and cooling systems, and even devices for cooking or cleaning each one of them trying ease our home chores, automate routine tasks or solve another particular problem humans have with homes. An example of such a problem, which has been relevant for a long time, and continues to be so, is securing your home. It's obvious and doesn't need any further explanation that we want to keep our personal belongings safe and at any time be sure that no one is accessing our private properties without our knowledge. The problem is, we can't know that for sure without an additional support when we are not physically in there.

It is quite common, particularly in Ukraine, to give a closely related person a key and ask to keep an eye on your apartment, when the whole family that lives there leaves for a vacation. Another quite common situation is people who live in the city where they work, but also have a private property a few hours away and either drive there from time to time just to make sure if everything is all right or call the neighbors to check on it. Even without these cases, there are periods of time in a day when we leave for work or school and the home is empty. At any given time it would be useful to be notified if someone's entering our home when we are not there.

Keeping in my mind these problems and applying the technical knowledge gained at the IoT class, this project is intended to be a simple solution to them, help the owner secure a home and be a third eye which is always inside and will notify the owner if someone enters a home when he/she is away. Such kind of a device might interest any home owner regardless of their age, gender, or place of accommodation.

Some of the devices available for sale offering a solution to a similar problem, but in a more sophisticated way with multiple extra features are the following.

Products

Home8 Oplink self-monitoring system [1]. Price 100$. Home8 Oplink AlarmShield provides security and monitoring for home or business. AlarmShield provides reliable monitoring of your home or business from anywhere in the world, and it seamlessly integrates multiple locations into one easy-to-use smartphone interface. AlarmShield provides fast, accurate alerts and notifications to just you or multiples authorized users. Consists of a Home8 Oplink processing unit, 2 door/window sensors, a motion sensor, a siren, and 2 remote controls. The following features are available through the app: video monitoring for multiple cameras, control the systems remotely. receive notification when alarm is triggered, customize multi-tier users and contacts, view history events, manage all devices from one place, event recording and sharing.

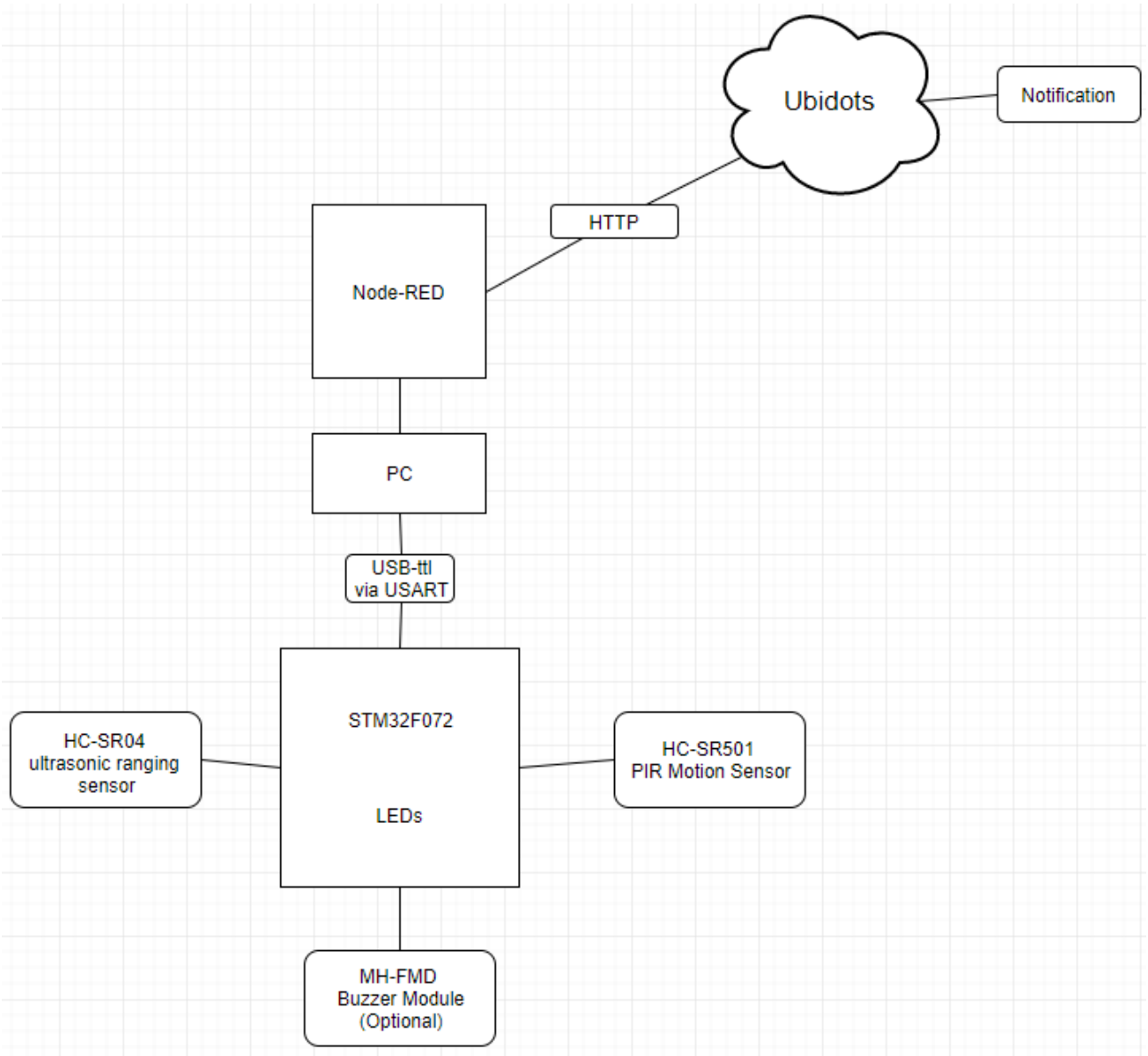
Ecolink Z-Wave door window sensor [2]. Price 36$. Also requires a Z-network to connect to. This sensor will let the owner monitor entry points to a home. The Ecolink_ Door/Window Sensor (DWZWAVE2-ECO) allows to keep track of the open/closed status of doors and windows throughout your home. Combined with SmartThings, this Z-Wave sensor can be used to turn your lights on or off, adjust your thermostat, send notifications, sound alarms, or do all sorts of other things when a door or window opens or closes. When connected to a Z-Wave gateway controller, a user can monitor open/close statuses when they are away from home, receive instant text and email notifications if anything has been tampered with or opened unexpectedly. Ecolink Door Window works simply but reliably: a sensor body is attached to the door or window frame, while a small adjacent magnet is attached to the door or window itself. When the structure is opened, the sensor and magnet are separated, immediately triggering the device.

Everspring Z-Wave Door/Window Sensor [3]. Price 30$. Also requires a SmartThings Hub to connect to (99$) [4]. The Everspring Door/Window Sensor is a Z-Wave-based contact sensor that can be used to monitor your doors, windows, and cabinets using SmartThings. It monitors activity at any entrance in a home. When the door or window is open, contact is broken between the sensor and the magnet, and the sensor signals the Z-Wave enabled system or alarm to alert you. Perfect for maintaining security or protecting valuables, the sensor can be installed in door frames, window frames, and along drawers and cabinets. When contact is broken, commands are automatically sent to up to four devices, turning on lights, setting off sirens, or any other application that has been programmed to report the sensor's state.

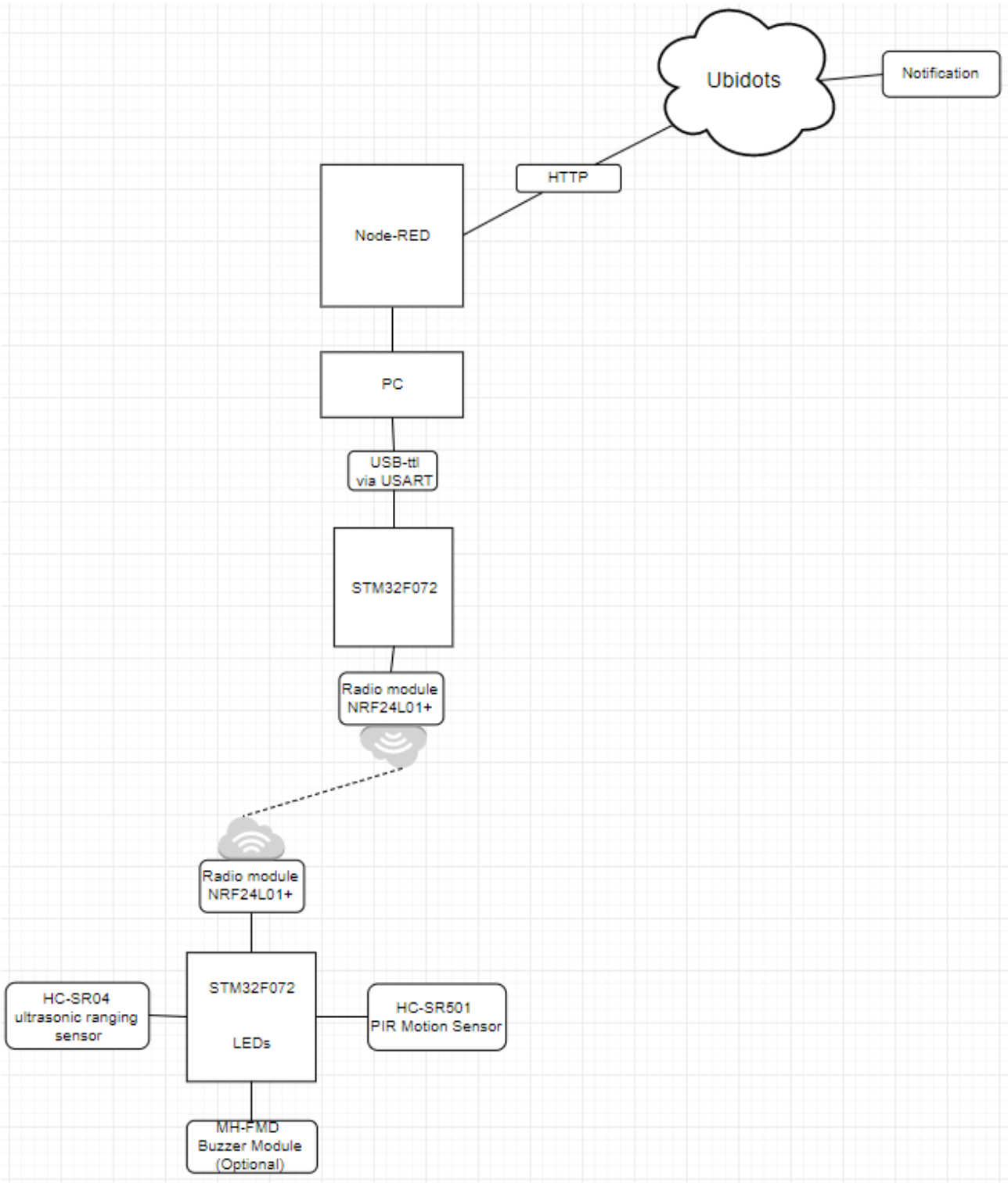
Methods

1) General architecture

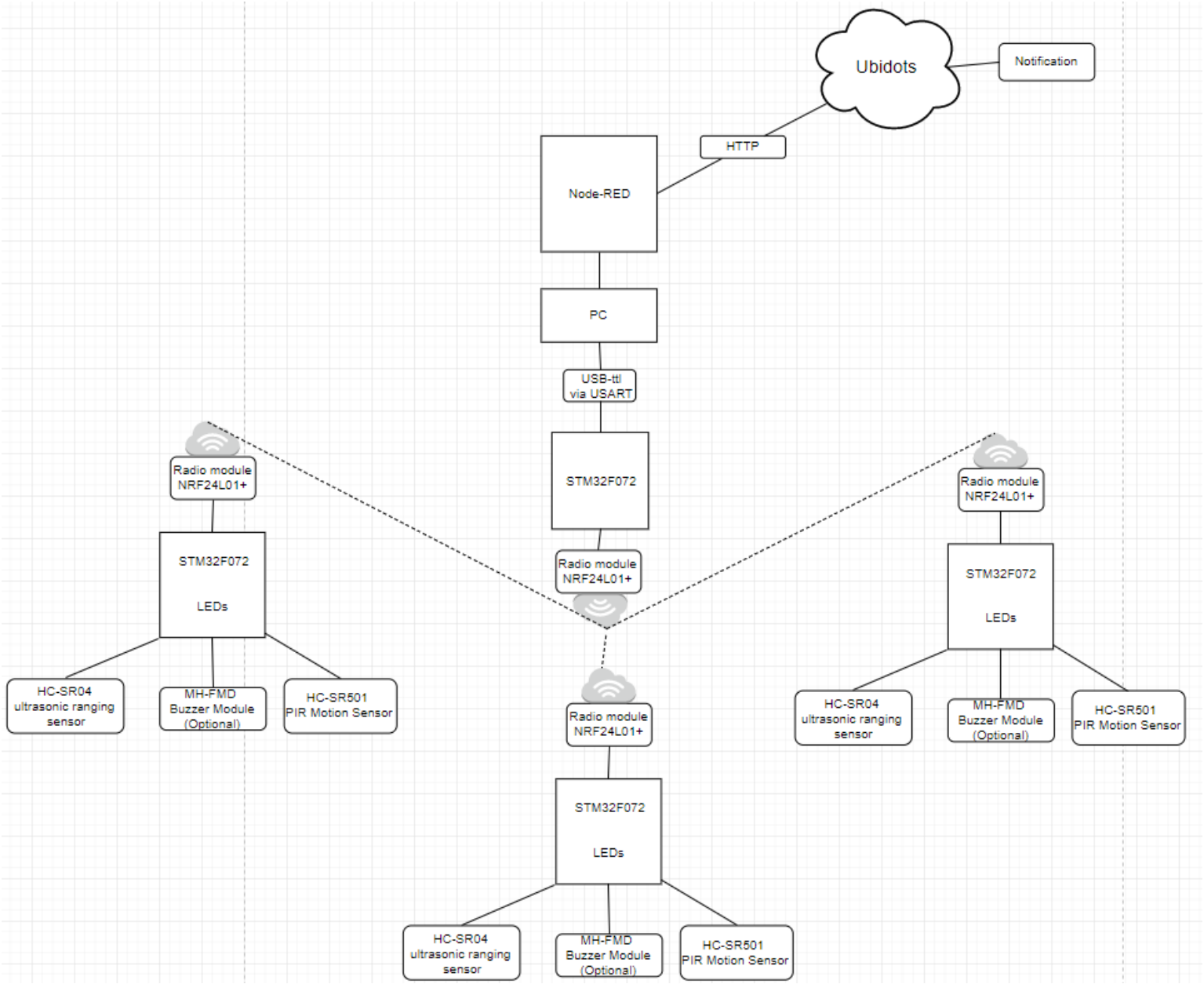
1-microcontroller configuration



2-microcontroller configuration



n-microcontroller configuration



2) List of components:

STM32F072RB microcontroller
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[6]http://www.st.com/content/ccc/resource/technical/document/datasheet/cd/46/43/83/22/d3/40/c8/DM00090510.pdf/files/DM00090510.pdf/jcr:content/translations/en.DM00090510.pdf

hc-sr501 motion sensor
[7] https://components101.com/hc-sr501-pir-sensor
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hc-sr04 ultrasonic ranging sensor
[9] https://cdn.sparkfun.com/datasheets/Sensors/Proximity/HCSR04.pdf
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MH-FMD buzzer module (optional configuration)
[13] http://tinkbox.ph/sites/tinkbox.ph/files/downloads/5V_BUZZER_MODULE.pdf
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nRF24L01+ radio module
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3) Responsibilities and steps

Steps:

1. Come up with an idea. Briefly research the field, applications of the idea and possible implementations.
2. Design the general architecture of the project and the general scheme of interaction and communication between components.
3. Gather all the needed sensors, microcontrollers, other components, and the supporting materials.
4. Learn how to work with different sensors and components and implement certain specific independent functionality in separate.
5. Implement the core features of the project all together, bringing multiple components and already implemented bits of code into one system, combining the hardware and the software.
6. Implement the communication with Node-Red and its functionality.
7. Integrate the cloud storage. Implement the data transmission, notifications and additional minor features.
8. Test the system and the correctness of separate components.

Table 1. Responsibilities

#	Name	Responsibility	Comment
1	Petro	Idea and research	
2	Petro	Working with sensors (ultrasonic, motion, etc)	
3	Petro	Implement communication via USART using USB-to-ttl	
4	Petro	Establish an api, a format in which data is sent and implement code for it	
5	Petro	Communication with Node-RED	
	Petro	Parse the incoming data, form the corresponding JSONs for further http requests	
6	Petro	Send data to the cloud server via HTTP	
…	Petro	notifications, etc…	

4) Behaviour of the system and explanation of the flowchart

Opened entry detection and hc-sr04 ultrasonic ranging sensor

The hc-sr04 ultrasonic ranging sensor is connected to a microcontroller and placed a predefined distance from an entry (for example a door) to a monitored area (apartment). When the door opens and the distance exceeds the threshold the system is triggered (also see 24-25). The observed distance value and other data is sent to Node-RED, then posted to Ubidots which will send a notification to the owner. Also in optional configurations buzzer can be enabled.

The hc-sr04 distance measurement is started by sending a trigger pulse through the trigger line of at least 10us to the SR04 sensor. This initializes the pulse emitting sequence which consists of emitting 8 40kHz ultrasonic pulses (200us in total). Once the 8 pulses have been emitted, the echo pin will change from a low to a high. This pin will remain high until the SR04 receives the pulses back or the module times out. This gives a pretty simple distance measurement flow. Send a 10us pulse, wait for the rising edge of the echo pin then start a timer, wait for the falling edge of the echo pin and stop the timer. The value present when the timer is stopped will be proportional to the distance of the object from the module. The accurate distance is calculated based on the time taken for the pulses to be received back and the speed of sound constant, taken into account that the pulses travel double the distance from the object (there and back).

Motion detection

hc-sr501 motion sensor is used to detect motion. There is not much need to explain about its measurements and how it works as they are included in the datasheets. As for the user of this sensor adding it to the project is relatively simple as it is connected almost like button. When the motion is detected, it is read from a pin on a microcontroller. The motion values (0 or 1) are also transmitted to the Node-RED and to the Ubidots which allows the user of the device to monitor the motion inside and set up additional notifications if needed. It is also a useful indicator combined with the entry sensor that will confirm if both the entry sensor was triggered and the motion detected then there is definitely an intruder. In a n-microcontroller configuration multiple motion sensors can be located in different rooms which will inform about movement in different parts of home.

USART communication

It was a quite time-consuming task as it involved many tries to make it work and finally implement the working code suiting the needs of the project. Multiple tutorials and videos [16-20] and many others were used for the learning purposes. USART is not supposed to be a hard task, but it made me stuck for a couple of days and I had to try and adapt code from multiple tutorials and examples, I've even tried stm32f3 USART communication and succeeded implementing it before finally making it work on the stm32f0.

In a nutshell, the sensor numerical values are converted to a char array (which was another time-consuming problem that for strange reasons caused compile errors and was fixed at the end by simply creating a new project in the ide without changing the code) and concatenated in a one single char array containing the device id, sensor name and the corresponding values and sent via USART.

Radio module communication

Radio module communication using the nRF24L01+ serves as a channel for data to travel wirelessly between the sensing components and a component that communicates with Node-RED in a multiple microcontroller configurations. The data sent is similar to the one in USART communication, the difference is that no wires are needed.

Node-RED

Node-RED is a crucial part of the whole system that listens for the data on the com port, gathers it all together and analyzes the device ids at the first stages. Then a string preprocessing takes place to convert it to the

format applicable for the JSON, after that the JSONs are formed. JSONs containing the data are sent in a http post requests to the corresponding device id at the Ubidots cloud storage using the Ubidots REST API.

Ubidots

Ubidots is a cloud storage that mainly allows to store, keep track and view statistics of all the data from different devices. In this project the REST API is used as a communication protocol between the Node-RED and Ubidots [26]. For further details about the tokens and in what form the post requests are formed the Ubidots documentation can be referred. Ubidots is also used as a tool for notifying the owner of the device.

Results

This project has been successful in implementing the distance measurement using the hc-sr04 ultrasonic ranging sensor and motion detection using the hc-sr501 motion sensor. Also the sensed data is successfully transmitted via USART. The Node-RED functionality has been implemented which allows to listen to the com port to read the data and process it accordingly as described in the Node-RED paragraph. Ubidots communication has been also established and tested for correctness when the data is sent to it every 1 second with one and multiple devices. As well as sample notifications have been sent to the mobile device.

Reference

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[16] Similar to the one used in project USB-to-ttl adapter
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