Bee-hives Monitoring using Internet of Things

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1 Introduction

In our project, we focus on bee-hives, perform their monitoring, hive control and thereafter notice the beekeepers about important changes that affect the quality and quantity of the honey production. The goal of the project is to simplify the beekeeper's work. Our solution is suitable for a professional and a hobby beekeeper. We use innovative technologies such as the Internet of Things, the Sigfox network, and various sensors to identify the amount of honey, bee swarming or to detect hive movement. We create an easy-to-use system for young and old people who are not familiar with modern technologies.

In comparison to our life, the bee´s life is just a minute, but it´s importance is enormous. According to this, we have decided to use modern technologies to help beekeepers perform the regular actions necessary for keeping the colony of bees. A professional beekeeper or one who takes bees as a hobby, needs to have an overview of the conditions of their hives. In most cases, the colony of bees is not located near the home, their place is in the nature, outside of the everyday civilization. Therefore, the great advantage would be to have this information without the need of the personal check. Those, who do not have regular access to their hives, will appreciate the possibility of remote control and early notifications of the unusual situations, that have would occurred.

One of the basic elements of our solution is to provide information about temperature inside the hive and outside. By monitoring the temperature, the beekeeper is able to detect a situation, when there is a lack of eggs, when is the right time to treat bees against pests or to detect the presence of mother. The most important moment in the life of the colony of bees is the presence of a healthy and fertile mother. Another element which we bear in mind is the weight of the hive. For laic it is just a number signing the presence of honey. For the beekeepers it is much more complicated. Last but not least, it is important to provide information about overturning of the hive or nowadays also about stealing the entire hive.

We proposed our system with usage of Sigfox technology, which cover much larger area than GSM base stations. Comparing to others, using Sigfox is very cheap and has lower consumption of the energy. On the other side, we use knowledge of existed works thus we use Arduino Mega 2560. We designed the system for web application and for android application. The main benefit is an early warning when something unexpected happens in the bee hive.

2 Related Works

Authors of *Honey Bee Colonies Remote Monitoring System* [1] designed a low-cost, reliable bee-hive-monitoring system based on wireless-sensor networks to measure the temperature, relative humidity, and weight of beehives in real time and non-intrusively. WBee as it is called, saves the data in each part of the network if there are failures in the communication.

The purpose of the device in the work *Telemetric measurement system of beehive environment conditions* [2] is to perform measurements of parameters such as ambient or internal temperature, atmospheric pressure, humidity and sound level. To accomplish the study, they decided to use the base module Arduino Mega 2560. The measured values were transferred to the MySQL database, which is located on an external server, with the use of GPRS protocol.

3 Solution Design and Technologies

Our proposed architecture consists of multiple components. Complete flow of data is shown in the Figure 1. The first part is Hive Monitor. It is composed of microcontroller - Arduino Mega 2560 with Sigfox antenna and sensors. Sensors perform

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measurements of the ambient and internal temperature, humidity, hive position and weight

DHT22 is accurate digital temperature and humidity sensor. To filter the noise from the environment, the producer recommends connecting the pull-up resistor to the DATA pin. The accelerometer includes a 3-axis gyroscope along with a 3-axis accelerometer. The sensor is based on a chip MPU-6050. For weight measurement we use TMOEC 200kg electronic load weight sensor.

Sigfox Transmitter communicate with devices connected to Sigfox network. It sends data from devices to the Sigfox Cloud Server. This server collects data from devices and by using HTTP Callbacks send data to our Bee Web Server.

On one side it hosts our website and on the other hand it is place, where the database is stored with all measured data. After receiving twelve bytes, the server parses these data and stores them. Despite this, the functionality of user login and registration is also implemented on the server. For providing measured data to beekeepers REST API is implemented on Bee Web server. It also provides authentication and registration of new users.

On our web page, we can find all information about project and about related technologies. Next, there is a simple form in section order, where the customer can order one or multiple devices. After registration, the beekeeper is able to follow up all new collected data or historical data. Web and mobile applications get data in JSON format using API calls. For better visualisation we have decided to use charts. Once the threshold limit is reached, the page displays a notification describing the problem. Whole this functionality is also implemented in Android application.

In Sigfox technology there is implemented protocol that allows you to transmit a small amount of data and has low power consumption, which is ideal for IoT. Each message is sent three times due to unreliable connection, each time at another randomly selected frequency. Maximum length of message is 12 bytes and each Sigfox end device sends up to 140 messages a day. This represents one message in about 10 minutes, so total daily capacity is 1680 bytes. IoT devices can communicate through Sigfox network. It uses Ultra-Narrow Band for communication and cells of this network allow to cover a much larger area than GSM base stations. Therefore, this technology is built on a cellular system similar to GSM and uses the star topology. The network operates in the 868 MHz band in Europe and 902 MHz in the USA. The maximum allowed transmit power is 25mW. The main advantage of this approach is that network can support large number of IoT devices. In Slovakia, Sigfox is provided only by one mobile operator – SimpleCell Networks Slovakia.

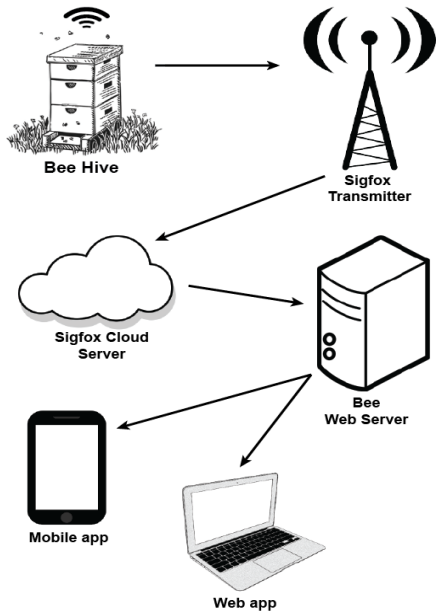

Figure 1 Suggested Solution Architecture

4 Conclusion

Our solution provides real-time bee-hive monitoring through Sigfox network. Communication is realized using Ultra-Narrow Band and cells of this network allow to cover a much larger area. Sigfox technology limits us to use only small messages which could be sent 140 times a day. Despite this limitation, the beekeeper regularly receives all actual information which are displayed on a web or Android application. With this in mind, our mobile application implements a notification feature, which triggers when an unexpected situation happens. For instance, when inside temperature is too high, or hive's position has changed. Above all, our future work could be focused on audio and video analysis for better prediction of the bee´s colony needs. Furthermore, it can be focused also on sending SMS message in case of exceeding the defined values.

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