Mouchak - An IoT Basted Smart Beekeeping System Using MQTT

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***Abstract*—Internet of things (IoT) is playing an enormous role to automate our world. In this paper, an automated IoT based system is proposed for beekeeping, where a smart prototype bee box is designed to monitor the bee colony. Using this system farmers can easily check the quantity of honey and wax. It will also provide necessary information about real-time temperature and humidity of the beehive. Moreover, a farmer can be awarded about the bee piping by monitoring the bee noises of the hive. Through this eco-friendly and cost-effective system, farmers can monitor their beehives characteristics from long-distance using a mobile application.**

Keywords-IoT; MQTT; agriculture; beehive; Arduino; beekeeping; piping; network

I. INTRODUCTION

One of the greatest of all time Albert Einstein says that “If the bee disappeared off the face of the Earth, man would only have four years left to live” [1]. Bees are one of the greatest vigorous elements of our earth. But among all the group of bees, honeybee is the most important creature because they not only produce honey and bees wax but also act as primary pollinating agents of many agricultural and horticultural crops. Honey can be produced naturally or by artificially which called beekeeping. About 75~80 % of natural production of honey comes from forest or hill areas and beekeeping is done by custom-made wooden boxes called honey box. One of the BBC reports shows that: The international demand for honey is very high, but the world is shortest of honey. Europeans consume an average of 0.7kg (1.5lb) of honey per year, and the EU is the world’s biggest importer, buying in around 200,000 tones (it is also the second-biggest producer of honey after China) [2]. To meet this huge demand of honey most farmers are focusing on beekeeping now. In these manmade artificial boxes, the bees are domesticated and maintained in colonies in proper management. In a bee-yard, farmers could have 500 to 1000 honey boxes at a time. That’s why to provide equal concentration on every hive is difficult for the farmers.

Figure 1. Traditional beekeeping in Bangladesh [3]

Figure 1 is showing one of the bee farming in Bangladesh where honey and wax quantity is checked manually. In this paper, a prototype system is design for monitoring honey boxes. This proposed model is an IoT based system where different sensors are used to observe different parameters inside the honey box. Then all the sensor data are processed through a microcontroller and finally, the system user can view all the sensor data by a mobile application. This proposed system is developed using

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the Message Queuing Telemetry Transport (MQTT) protocol of data integration and communication to the hardware system with local server and mobile application.

II. RELATED WORKS

A research considering architecture and functionality of the embedded data acquisition system for automated beehive monitoring was done by V. G. Rybin, D. N. Butusov, T. I. Karimov, D. A. Belkin and M. N. Kozak [4]. Where the researchers have researched bee piping and different behavior of honeybees. Another work which goal was to use wireless sensor network technology to monitor a colony within the beehive with the aim of collecting image and audio data was done by F. E. Murphy, M. Magno, L. O'Leary, K. Troy, P. Whelan, E. M. Popovici [5]. A. Draper shows the relationship between the ecosystem's contamination and the behavior of bees where a device was developed for samples audio and temperature in hives [6]. Another group of researchers has introduced a wireless platform weighing scales for a smart beehive system. A single point impact load cell was selected as the most appropriate load sensor and was integrated into the design of the scales which was done by D. W. Fitzgerald and his team [7]. A smart node monitoring system was proposed to alert to the beekeeper by F. E. Murphy. The automated wireless audio recording node was designed to work with a large sensor network to monitor the health and conditions of the beehive [8].

III. ARCHITECTURE MODEL

In this microcontroller-based proposed system, the ESP8266 microcontroller is performing both as controlling and the networking connector. All the sensors are connected with the main Microcontroller and an LCD display module is connected for showing the real-time hardware result. After fetching all the data from the sensor microcontroller executes its operation and all the sensor data first decoded and then sent into the MQTT server.

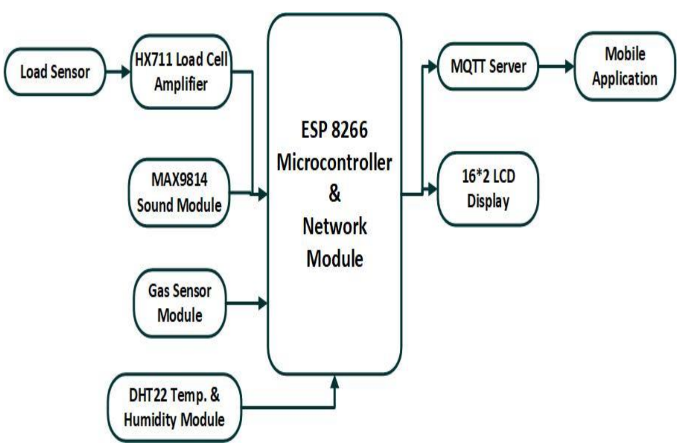

Figure 2. Architecture model of the system

Fig. 2 shows the main architecture model of this proposed system. Fritzing simulation tool [9] is used to design the proposed system diagram which is shown in Fig. 3.

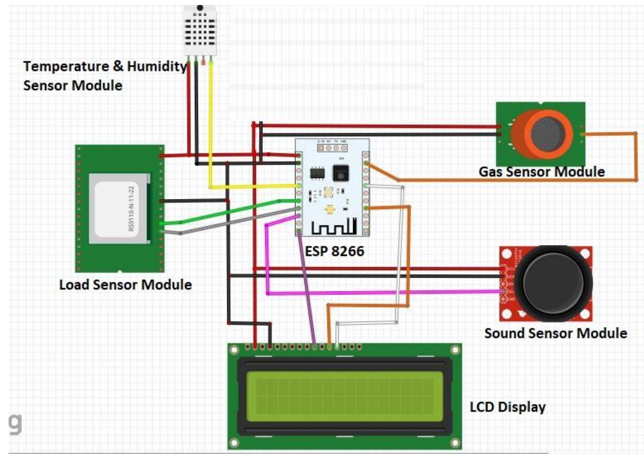

Figure 3. Simulation diagram of the proposed model

The mobile application will communicate with the local MQTT server and by using this app the user can easily monitor the different sensor parameters in the bee box. Not only the app but also the LCD display will show the status.

IV. HARDWARE MODEL

For testing this system, a prototype bee box is designed containing all the required sensors assembled in the box.

Figure 4. Designed prototype bee box

Fig. 4 shows the hardware model of the prototype bee box. This designed bee box can calculate the total load, sense the current temperature and humidity inside the bee box, specified noise of bee piping and gas status surrounding the box.

A. ESP8266

The ESP8266 microcontroller integrates a Tensilica L106 32-bit RISC processor to achieves low power consumption and it had a maximum clock speed of 160 MHz [10]. It also performed as a real-time operating system (RTOS) controller and its Wi-Fi stack allows about 80% of the processing power makes it a powerful. With highly integrated on-chip features and minimal external discrete component count, this microcontroller offers reliability, compactness, and robustness. In the system, this microcontroller is used for processing all the sensor data and also sent the data to the cloud or MQTT server.

B. Sound Module

For monitoring the bee piping a sound sensor module had been install with the system. MAX9814 sound model is a low-noise preamplifier and has a fixed 12dB gain, while the VGA gain automatically adjusts from 20dB to 0dB, depending on the output voltage and the AGC threshold [11].

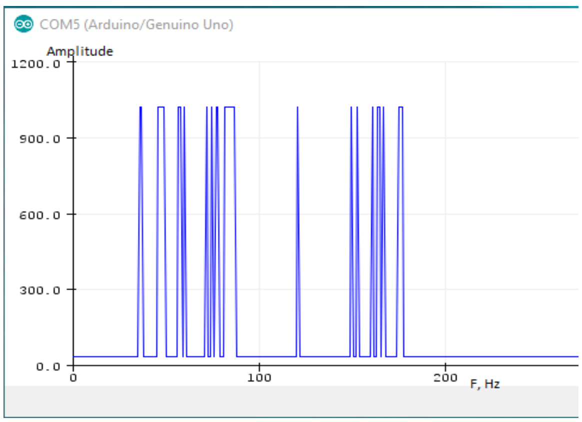

Figure 5. Bee piping amplitude

Swarming is a major fact in beekeeping. Capturing swarms and attempting to stop swarming consumes a lot of beekeeper labor [12]. It's well known that bee piping is a special sound, emitted by young queen bees and bee piping is the sign of the swarming approaching. So, monitoring the bee piping is not so easy task. This system can measure the real-time amplitude signal of the bee colony. The hardware result of piping amplitude measurement is shown in Fig. 5.

C. Load Sensor & Gas Sensor

Figure 6. Load sensor result

The main purpose of the load sensor is to measure the current weight of a honey box. In this proposed system a strain gauge load sensor is used with an HX711 load cell amplifier model. After connecting with the microcontroller, the change in the resistance of the load cell will calculate the total load. Fig. 6 is showing the real-time result of the load sensor. If the quantity of honey and wax increases in the box farmers can easily define that. Also, a gas sensor module MQ2 is used in this prototype to monitor the gas surrounding the honey box. The used gas sensor can detect LPG, Alcohol, Propane, Hydrogen, CO and even gasses like methane. As gas can harmful for honeybees. So, it is very much important to monitor the unusual gas parameters around the honey box.

D. Temperature and Humidity Sensor

A digital temperature and humidity sensor DHT22 module is used for this prototype to monitor real-time temperature and humidity inside the honey box.

Figure 7. Temperature and Humidity inside the bee box

Here in Fig. 7 the real-time temperature and humidity in the designed bee box is shown.

E. Message Queuing Telemetry Transport Protocol

Message Queuing Telemetry Transport Protocol (MQTT) is a machine-to-machine (M2M) connectivity protocol. Extremely lightweight publish/subscribe messaging transport can transfer between nodes using MQTT [13]. A local mosquito server is installed for MQTT local database. All the sensors are performing as a publisher to MQTT broker or database and the mobile application is subscribing to the broker to view the published results.

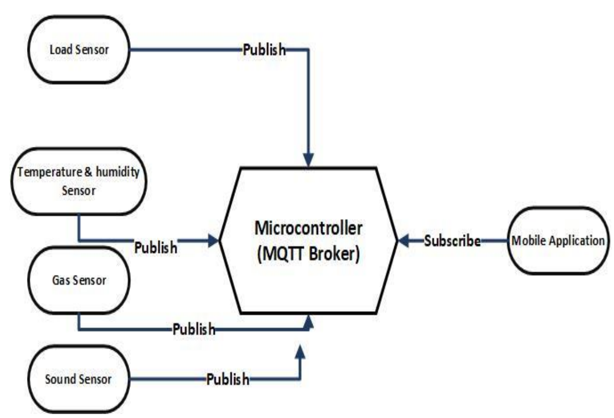

Figure 8. MQTT Working Process

Here in Fig. 8, the basic working principle of the MQTT protocol for the prototype system is shown. All the sensors are connected with the local mosquito database with the microcontroller ESP8266. Here, ESP8266 is the default gateway for all the sensors. After the successful connection with the broker, all the data are stored in the mosquito database, to see the data a user has to be subscribed on the database with a mobile application.

F. Mobile Application

For this system, an open-source mobile application is used which supports the MQTT protocols. This application is customized with a symbolic icon for different sensors results for better user experience.

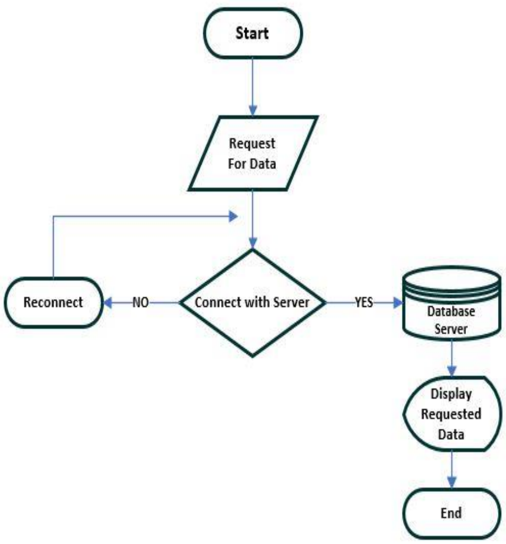

Figure 9. Basic Architecture model of the mobile application

Fig. 9 is showing the working architecture model of the used mobile application. After connecting with the local database, a user can easily monitor the sensor parameters of the bee box.

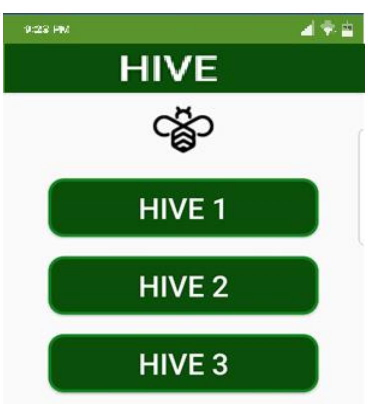

Figure 10. User interface of the mobile application

Here, Fig. 10 is showing the user interface of the mobile application where the user can select the bee box number to see current status of the desired box. The following figure shows the sensor status of a specified bee box.

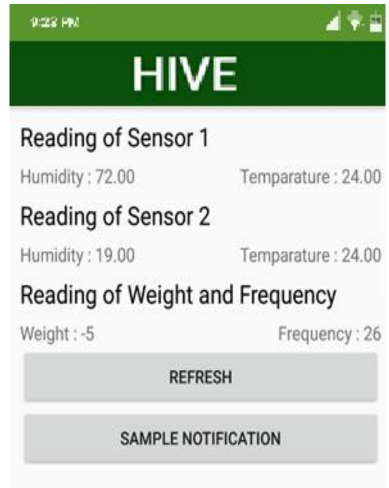

Figure 11. Results showing in the mobile application

V. COSTING

It's a cost-effective prototype model and Table I shows the costing of this prototype.

TABLE I. COST ANALYSES FOR THE PROTOTYPE SYSTEM

Name of the Equipment	Quantity	Cost in BDT
ESP8266	1	500
Battery 2.5V 1A	2	200
Sound Sensor	1	400
Gas sensor	1	350
Temp. Sensor	1	450
LCD display	1	120
	Total	**2020 BDT**

VI. ADVANTAGES

The listed aspects show effectiveness of this system which made it a strong candidate for implanting in real life.

- Easy to manage and monitor all the beehives at a time.
- Notified automatically about the overflowing of honey and wax for any specified box.
- Bee piping data is useful for monitoring the labor bee's behavior.
- Easy to implement and cost-effective.
- Low power consuming system.

VII. CONCLUSION

In this proposed system all the sensor values are calculated from a prototype environment. But this prototype system can be implemented in real life. The whole hardware system is operating at and 2A current. In addition to its low power consuming and the mobile application interface makes it more user-friendly. By implementing this proposed system, farmers can easily monitor their bee-yard efficiently and effectively. This system will help to identify specific box full of honey and wax which is more convenient and less laborious for a farmer. In future, the designed bee box model can be improved by adding more sensors and modified algorithms for smoothing the usage of this proposed system-"Mouchak".

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