# Development of Intelligent Beehive and Network Monitoring System for Bee Ecology

**Chau-Chung Song[a,b*], Geng-Yi Lin[a], Chi-Chung Peng[c] and Chung-Wen Hung[d]**
[a]*Department of Aeronautical Engineering, National Formosa University, Yulin, Taiwan*
[b]*Smart Machine and Intelligent Manufacturing Research Center, National Formosa University, Yulin, Taiwan*
[c]*Department of Biotechnology, National Formosa University, Yulin, Taiwan*
[d]*Department of Electrical Engineering, National Yunlin University of Science & Technology*

[*]*E-mail: ccsong@nfu.edu.tw*
*www.nfu.edu.tw*

**Abstract**

In this paper, development of intelligent beehive and network monitoring system for bee ecology is focused on data acquis such as temperature, humidity, weight, and GPS positioning, combining the beehive with MCU, sensors, and ZigBee to implement front end sensing nodes to build a bee ecological network monitoring information system for real-time remote network monitoring, and assist beekeepers to establish a cloud-based real-time monitoring system and history traceability Bee product management system to enhance the convenience of beekeeper management and risk control, thereby effectively improving the efficiency of labor utilization. Also, clear production history information can increase consumers' trust in products and enhance the overall bee-related industry Economic benefits. This paper cooperated with beekeepers in Gukeng, Yunlin County, set up an Intelligent beehive system in the bee farm. Observations in the past month have shown that the activity and number of adult bees and larvae grown in the intelligent beehive are in good condition, user can also connect to the Intelligent beehive monitoring website through their mobile phone, tablet, or computer to analyze and monitor the status of each beehive.

*Keywords*: Intelligent beehive, Bee ecological information system, Real-time monitoring system.

## 1. Introduction

B Bees play an important role in agriculture, such as pollinating crops, producing a variety of bee products, and creating high agricultural economic output. The overall output value of bee products in Taiwan has reached NT$2.3 billion. The current intelligent beekeeping products use intelligent systems to grasp the status of the colony in real-time, such as monitoring the weight of the colony to know the amount of honey and determining when to harvest. Also reflect the health status of the bee colony by monitoring the data to prevent the problem from worsening or spreading. However, beekeepers in Taiwan still use traditional methods for nurturing and management, which are not only laborious and time-consuming but also disturb the bee colony. Furthermore, with increases in labor costs in rural areas and the general shortage of beekeeping manpower, the beekeeping industry is facing development difficulties and serious management challenges. [1-2]

## 2. Methods

### 2.1. *Environmental sensor module design*

The intelligent beehive detecting ecology of bee colony has 4 main functions.

#### 2.1.1 *Temperature and humidity sensing*

Temperature and humidity are highly related to honey

quality and bee colony conditions. [3]

2.1.2 *Weight sensing*

Monitoring the weight of honey can grasp the progress of honey collection by bees, and store and record daily beekeeping data. The maximum measuring weight of the weighing platform is 80kg, the resolution is 0.1kg, and the error range is ±5%.

2.1.3 *Beehive positioning*

With accurate positioning information, productivity records, and beehive environment data of deployment spots in seasons, beehive transfer plans can be made more cost-effectively.

2.1.4 *Wireless sensor network*

With wireless sensor networks and Internet of Things technology, beehive and bee colony status can be collected in real-time, also overcome the data collection difficulties of smart beehives deployed outdoors and achieve the function of collective remote beehive monitoring. More, a large number of beehives can be monitored at the same time.

## 3. System Design and Architecture

In the system, wireless sensor network of beehive environment sensor groups containing several sensor nodes is connected to an online database and system server by heterogeneous network gateway to provide remote monitoring of system status and create production records which help to build both the production decision system and production and sales resume system. Big data analysis system for detecting and diagnosing the ecology and health of bee colonies can be built with huge amounts of data. The system architecture is shown in Fig.1.

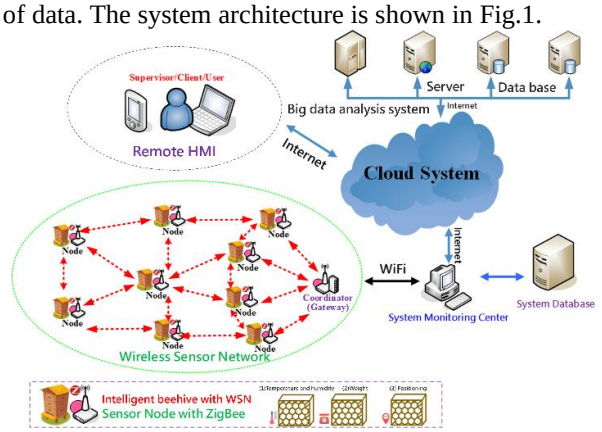



Fig. 1. The system architecture of Intelligent beehive and network monitoring system for bee ecology

### 3.1. *Wireless sensor network*

The wireless sensor network architecture is shown in Fig.2. When a beehive that has a Zigbee coordinator receives a packet from other node beehives, it repacks the data and uploads it to the cloud via Wi-Fi in JSON for further usages like production management or bee ecology and health of bee colony, etc. [4-5]

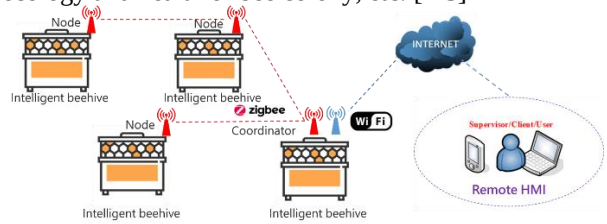



Fig. 2. The wireless sensor network architecture

### 3.2. *Cloud management system*

The webpage interface and the database server are based on WampServer which is an open-source integrated installation environment containing Apache Web Server, MySQL, and PHP. The Cloud network management system architecture is shown in Fig.3. [6]

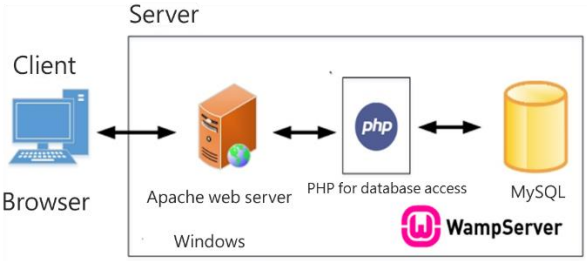



Fig. 3. The Cloud management system architecture

### 3.3. *Remote monitoring system*

The remote monitoring interface is a cross-platform browser-based application developed with HTML for the webpage, JavaScript for Interactive behavior, and CSS for layout. Data transfer via Asynchronous JavaScript and XML(AJAX) and HTTP POST between client and server. The server access database via PHP. The remote monitoring system architecture is shown in Fig.4.

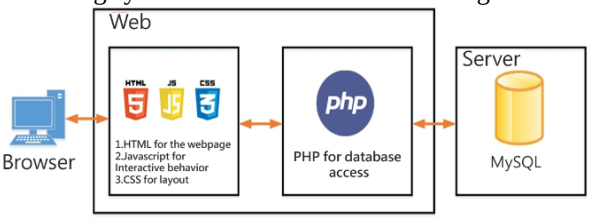



Fig. 4. The remote monitoring system architecture

## 4. Experiment results

### 4.1. *Environmental sensor module components*

Environmental sensor module components two main parts, "intelligent beehive main unit" and "weighing platform". In order to maximize the accessibility of the system to beekeepers, parts selections are optimized to meet the minimum system requirement and low cost. The components list is shown in Table 1.

Table 1. Components list [7]

| Model | Parameter | Specification |
|---|---|---|
| Si7021 | Humidity | 0~100%, resolution 0.01% |
| | Temperature | -10℃~80℃, resolution 0.01 |
| AT8502 | Weight | The weighing platform can measure up to 80kg with a resolution of 0.01kg. |
| NEO-6M | Positioning | GPS latitude and longitude, the error distance is less than 100 meters. |
| - | Input Voltage | 110VAC/60Hz |
| - | Spare Battery | Lithium Battery 3.6V (3250mAh), 3S |

#### 4.1.1 *Main Unit of Intelligent Beehive*

Main unit of Intelligent beehive as shown in fig.5 uses 110V/60Hz AC city power as the main power source. An internal backup lithium battery provides about 20 hours of backup time without the main power source. The positioning module and ZigBee module are installed in a dust/waterproof box to increase system durability in tough environments.

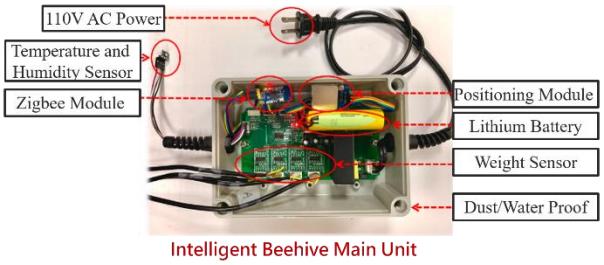



Fig. 5. Main Unit of Intelligent Beehive

#### 4.1.2 *Weighing platform*

The weighing platform as shown in fig.6 is made of painted stainless steel to provide rust resistance for the outdoor environment.500*640mm platform size fits the general size of most beehives.

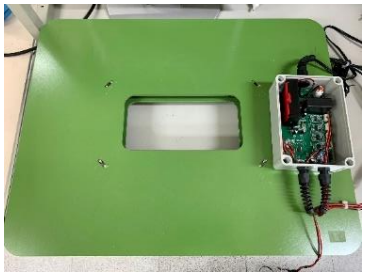


Fig. 6. Weighing platform

#### 4.1.3 *Sensor module component configuration*

The positioning module and communication module are located in the dust/waterproof box of the beehive main unit. A beehive is placed on the top of the weighing platform. A humidity sensor is installed inside the beehive at 2/3 interior height to avoid stagnant water Influence. Component configuration as shown in Fig.7.

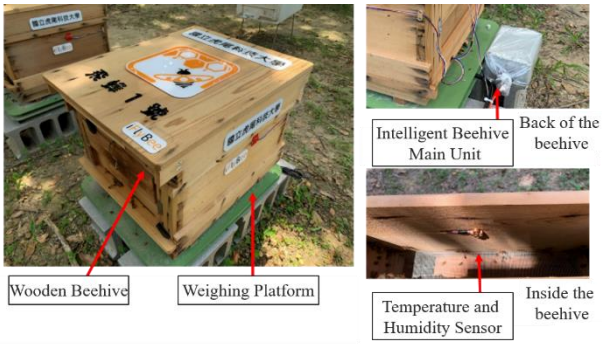



Fig. 7. Component configuration

### 4.2. *Monitoring and recording system*

The web page interface shown in Fig.8 provides visualized real-time temperature, humidity, weight information of each beehive set to users using a mobile phone, tablets, computers, or any web browsing device.

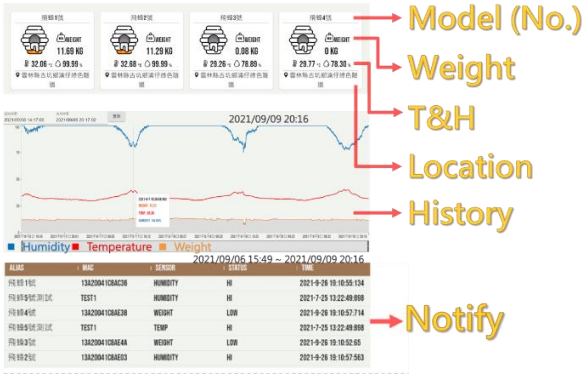



Fig. 8. Web page interface

## 5. Conclusion

In this paper, a series of sensor modules, wireless sensing network systems, cloud network management systems, remote monitoring systems, etc. are designed based on the bee ecological remote network monitoring and recording system, integrated and applied to bee ecological monitoring and recording. And cooperated with beekeepers in Gukeng, Yunlin County, set up an Intelligent beehive system in the bee farm, assist beekeepers to establish a bee product management system with real-time monitoring system, digitization, and traceability of histories to improve the convenience of beekeeper management and controlling the risk, thereby effectively improving the efficiency of labor utilization. Clear production history information can increase consumers' trust in products, improve the overall economic benefits of bee-related industries, and accelerate domestic research and development of intelligent beekeeping and related industries. The key application technology promotes the transformation and upgrading of the domestic beekeeping and bee products industry.

## Acknowledgements

This research was supported by the Miaoli District Agricultural Research and Extension Station, Council of Agriculture, Executive Yuan, R.O.C., Research project: "Development of Intelligent beekeeping monitoring system," under Grant: 109I065-04.

## References

1. Chen, Y. T.& Zhang, Y.X., *"Global bee industry issues and the current development of Taiwan's bee industry"*, Agricultural Biotechnology Industry Quarterly, Issue 52 (2017/12/31), P53-57.
2. Huang, W. Z., "High-tech Save the Bees", Commercial Times, 2016/10/30.
3. H. F. Abou-Shaara1, A. A. Owayss2,5, Y. Y. Ibrahim3, N. K. Basuny (2017). A review of impacts of temperature and relative humidity on various activities of honey bees. Insectes Soc., 64, 455-463.
4. ZigBee Alliance.
5. ZigBee Alliance, "ZigBee-Specification-2006-Download.pdf", http://www.ZigBee.org/.
6. WampServer official website.
7. Silicon Laboratories, "AN607: Si70xx Humidity Sensor Designer's Guide", 2016.

## Authors Introduction

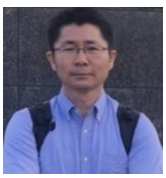
Chau-Chung Song

Chau-Chung Song is with the department of Aeronautical Engineering, National Formosa University, Taiwan. He received the M.S. degree in Control Engineering in 1994 and the Ph.D. degree in Electrical and Control Engineering from National Chiao Tung University in 2001 in Taiwan. He is currently a professor in the Institute of Aeronautical and Electronic Technology, and Department of Aeronautical Engineering, National Formosa University since 2006. His research interests include the analysis and control of nonlinear systems, power electronics applications, integration application of networking information systems, UAV technology and applications, cloud networks, and Cyber-Physical system (CPS).

Geng-Yi Lin

Geng-Yi Lin received his Bachelor's degree from the Department of Aeronautical Engineering, National Formosa University, Taiwan in 2021. He is currently a Master's course student in National Formosa University, Taiwan.

Chung-Wen Hung



Chung-Wen Hung received the Ph.D. degrees in Electrical Engineering from National Taiwan University in 2006. Currently he is an associate professor in National Yunlin University of Science & Technology. His research interests include IoT, IIoT, Power Electronics, Motor Control, and AI Application.