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A Rabbit Farm Environmental Monitoring System based on Internet of Things

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Abstract

On account of the low degree of automation in a rabbit farm, this paper proposes a rabbit farm environmental monitoring system based on internet of things. First, this paper designs a rabbit farm environmental monitoring system according to the three-tier architecture of the internet of things. Then it chooses a wireless transmission module as required by the system in addition to the proposal of a new gateway initialization flow for the internet of things. After that, it analyzes the flow to query the farm monitoring data and the flow of reverse control on the environmental parameters to verify finally the feasibility of the system through the experiment.

Keywords: *Agricultural Internet of Things; Automation in Rabbit Farms; Monitoring of Environmental Parameters*

1. Introduction

Rabbit keeping has become one of the most effective approaches [1-3] to revitalize rural economy, helping the farmers to get rid of poverty and become rich. Since all of the following factors including the temperature, the humidity, the content of the harmful gas and the illumination *etc.*, in a rabbit farm will affect the growth of a rabbit [4-5], then rabbit farm can be considered as an important factor to affect the growth of rabbits and the production economic yield. In view of this, monitoring on the rabbit farm will facilitate the disease control & prevention and the disease warning, able to create a favorable living and production environment for the rabbits. It's actually an effective approach to keep the rabbits in good health, improve the productivity and increase the economic benefit. Through the traditional method, regular manual inspection and measurement has been adopted to monitor the rabbit farm. It requires lots of manpower and material resources, but gives big error in data with poor accuracy.

Now the continuous development of the internet of things technologies, which have become increasingly mature, is able to provide a new solution for the monitoring of rabbit farms. The internet of things technologies refer to such technologies as RFID, sensor and GPS etc. with the utilization of multiple communication modes to connect things to the internet so that things can be connected with each other according to the relevant network protocol to realize intelligent management over the internet[6-7]. Such an internet is able to provide the functions of sensor monitoring and data query on a distributed Web Service platform in addition to the interaction between the various application services on a cloud computing platform. The architecture of the internet of things can be integrally divided into three layers, which separately are the perception layer, the network layer and the application layer [8].

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Based on the internet of things technologies, this paper proposes a rabbit farm environmental monitoring system, which can be used to measure the environmental parameters in a farm about the monitoring on the temperature, the humidity and the harmful gas etc. All of the measured data can be uploaded to the cloud server, to which the users can get access to review the data about the rabbit farm and at the same time, they can control the node equipment's through the APP. This system is able to increase the degree of automation in monitoring the farming environment, providing a theoretical basis for the intelligent rabbit farming.

2. System Architecture

As shown in Figure 1, the internet of things-based rabbit farm environmental monitoring system has been designed based on the three-tier architecture [8] of the internet of things.

The network layer: Cloud network consists of the high-performance Gigabit LAN, the high-bandwidth internet and the 4G mobile network. Web server can be connected to the rabbit farm and the apps on a mobile phone through the indoor WiFi LAN, the high-bandwidth internet or the 4G mobile network. In this paper, choose the stable high-bandwidth router as the host hardware. The connection between the Web server and the data server can be established through the high-performance Gigabit LAN, while the gateway will be connected to the sensor with a 433M wireless module for the transmission.

The perception layer: Configure the sensors and the corresponding hardware devices controlled through the gateway. In information acquisition, information that has been collected in the sensor will be sent to the gateway, where data interaction with the server in the application layer and the APPs on the cell phone will be realized through the cloud network after the gateway receives the information.

The application layer: It consists of the web server, the data server and the APPs on the cell phone, among which the web server is used to process information and the service logic. The data server is used to store data in addition to the computation on the database stored procedures. Through the APPs on the cell phone, the users are able to review the environmental parameters and control the hardware devices connected to the gateway so that the environmental parameters can be adjusted artificially.

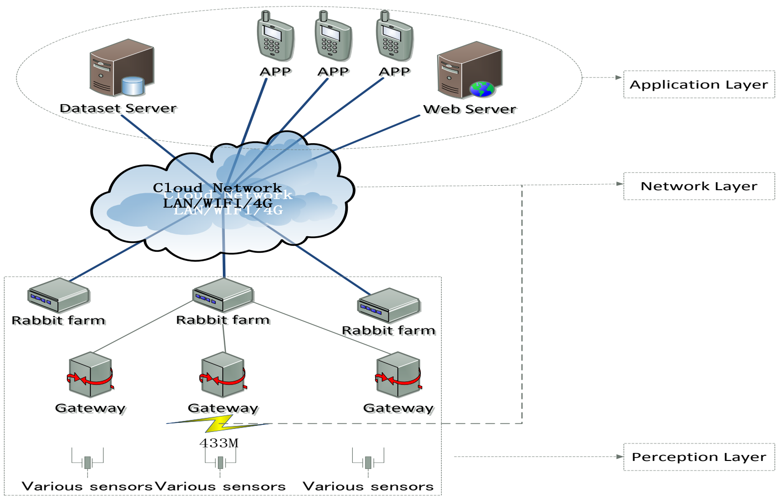

Figure 1. Overall Architecture of the System

3. Key Technologies of the System

3.1. Wireless Transmission Module

In the internet of things, the common transmission modes between the gateway of the internet of things and the sensor node have always been implemented through the wireless LAN, Zigbee, Bluetooth or the RFID [9-10]. Table 1 gives a comparison between Wifi, Zigbee and the 433M wireless transmission.

Table 1. Comparison of Three Wireless Transmission Technologies

	Wifi	Zigbee	433m
Coverage	50m	10m	1000m
Cost	High	High	Low
power consumption	High	Low	Low
Bandwidth	100M	250k	5k
Battery life	A little low	High	High
Stability	High	A little high	High

The 433M wireless module is a new generation of embedded multi-channel wireless data transmission module with the operating frequency between 433.4 and 473.0MHz[11], capable to be configured into multiple channels with each step frequency at 400KHz for totally 100 steps. The maximum transmitted power of this module is 100mW (20dBm), while the receiving sensitivity is -116dBm when the over-the-air baud rate is 5000bps. This module shows a high degree of frequency stability with the communication distance up to 1000m in an open area. When the ambient temperature varies between －25 and +85 degrees, the frequency drift of this module is only 3ppm/degree. In fact, rabbit farm has always been built in a large area with low data traffic generated in the monitoring of the farming environment. Since the 433M wireless transmission technology is featured with the following characteristics, including low cost and long transmission distance without the limitation on the number of the bytes to be transmitted in one time, it’s more applicable to the monitoring on the environmental parameters in a rabbit farm compared with the other wireless transmission technologies. Hence this paper chooses HC-12 SI4463, which is a wireless single-chip serial module to realize data transmission between the gateway and the sensor nodes.

3.2. Gateway Initialization Flow

In an internet of things-based rabbit farm environmental monitoring system, gateway initialization is a key step for the following reasons:

(1) The communication between the gateway and the server is established through the Wifi deployed within the rabbit farm. However Wifi password must be inputted on the gateway.

(2) Rabbit farm has always been constructed in a large area. In the case that there’re many gateways available, it’s necessary to initialize all of the gateways in one time.

(3) It’s very likely that the server IP address deployed on a server might be changed.

This paper proposes a complete gateway initialization flow with the flow chart as shown in Figure 2.

Step1:First, input the correct Wifi password and the server IP address to the Client App. Then test if the APP has been connected to the Web server. If no, continue to input the correct Wifi password again. If yes, go to Step 2.

Step2:Obtain the gateway ID by scanning the barcode attached in advance on the gateway through the client APP. Then package the user name, the password and the gateway ID into a json packet for the transmission to the web server. After that, wait for a result from the web server.

Step3:After the web server receives a request from the Client APP, it will verify the validity of the gateway id and the user name contained in the JSON packet. If validation should succeed, the web server will return a command of Validation Success to the client APP.

Step4: When the client APP receives a result from the web server about the successful validation, it will be disconnected from the web server. However in order to initialize simultaneously multiple gateways, an AP connection will be created through the client APP at this moment. The flow chart for the transformation of AP through the Client APP is shown in Figure 3.

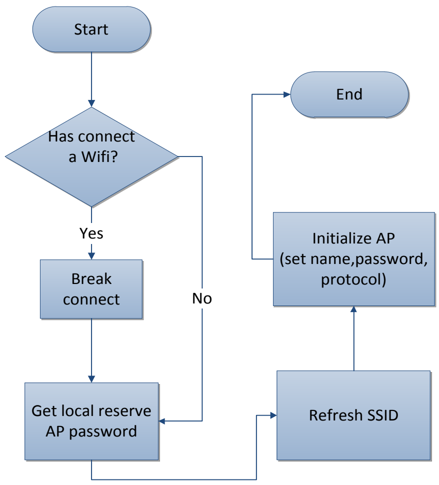

Figure 2. Gateway Initialization Flow Chart

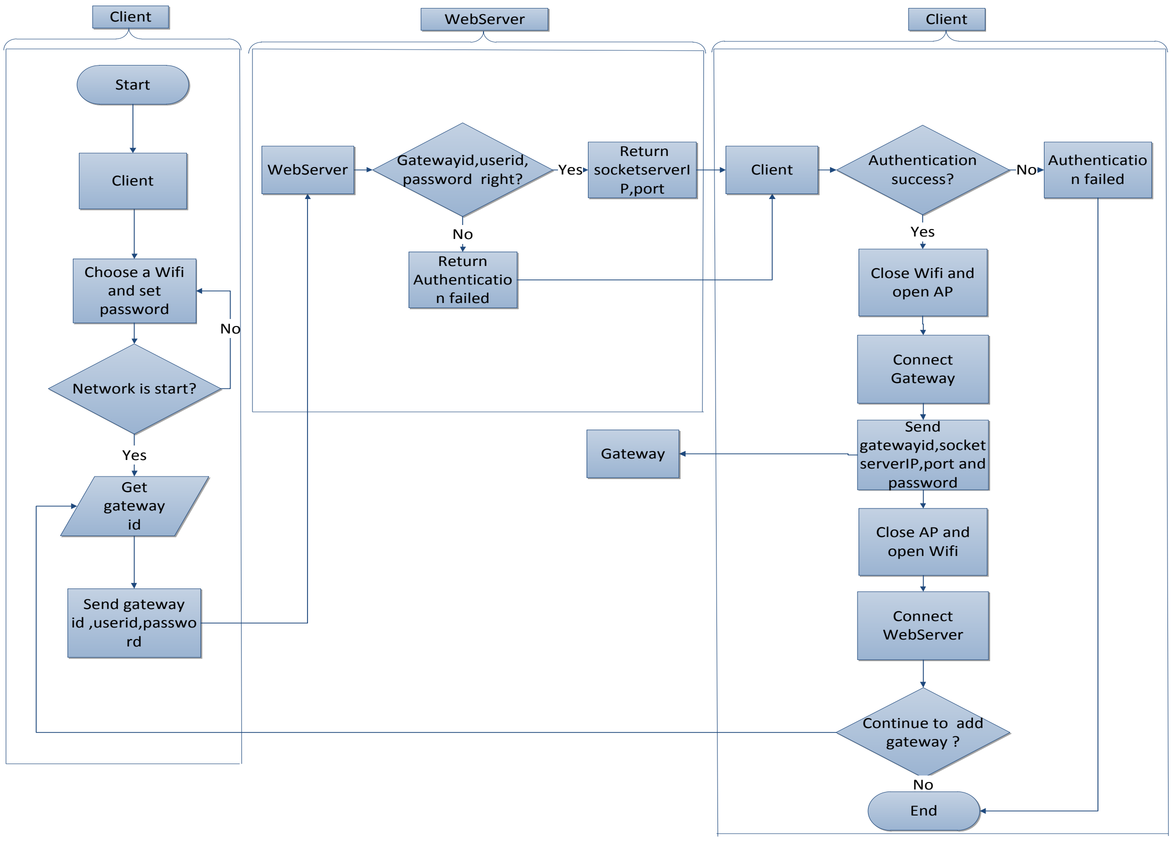

Figure 3. The Flow Chart for the Transformation of AP through the Client APP

Figure 4 is an example of the App on an Android client, showing the key codes for the transformation of AP on the client end. The AP name and the password generated through the client APP have been preset in the APP and the gateway. Then as soon as AP has been created successfully according to the preset configuration, multiple gateways will be connected to this AP connection automatically. At this moment, wait for the broadcast data from the Client APP.

```
/**
 * OPEN AP
 * @param mSSID
 * @param mPasswd
 */
public void stratWifiAp(String mSSID, String mPasswd) {
    Method method1 = null;
    try {
        method1 = wifiManager.getClass()
                .getMethod("setWifiApEnabled", WifiConfiguration.class, boolean.class);
        WifiConfiguration netConfig = new WifiConfiguration();
        //SET SSID'S NAME
        netConfig.SSID = mSSID;
        //SET SSID'S PASSWORD
        netConfig.preSharedKey = mPasswd;
        netConfig.allowedAuthAlgorithms.set(WifiConfiguration.AuthAlgorithm.OPEN);
        netConfig.allowedProtocols.set(WifiConfiguration.Protocol.RSN);
        netConfig.allowedProtocols.set(WifiConfiguration.Protocol.WPA);
        netConfig.allowedKeyManagement.set(WifiConfiguration.KeyMgmt.WPA_PSK);
        netConfig.allowedPairwiseCiphers.set(WifiConfiguration.PairwiseCipher.CCMP);
        netConfig.allowedPairwiseCiphers.set(WifiConfiguration.PairwiseCipher.TKIP);
        netConfig.allowedGroupCiphers.set(WifiConfiguration.GroupCipher.CCMP);
        netConfig.allowedGroupCiphers.set(WifiConfiguration.GroupCipher.TKIP);
        method1.invoke(wifiManager, netConfig, true);
    } catch (IllegalArgumentException e) {
        e.printStackTrace();
    } catch (IllegalAccessException e) {
        e.printStackTrace();
    } catch (InvocationTargetException e) {
        e.printStackTrace();
    } catch (SecurityException e) {
        e.printStackTrace();
    } catch (NoSuchMethodException e) {
        e.printStackTrace();
    }
}
```

Figure 4. The Key Codes for the Transformation of AP through the Android APP

Step5: Through the client APP, the Wifi password and the user information that has been sent from the web server will be sent to the gateway. After the gateway receives the information, the client APP will be run in the Wifi mode again for the reconnection with the web server. At this moment, wait for the connection between the gateway and the server.

Step6: As soon as the gateway is connected to the web server successfully, the data server will be refreshed by the web server, indicating also that the gateway initialization completes.

3.3. The Process to Query the Farm Monitoring Data and the Reverse Control

The gateway periodically sends the data to the web server, where data will be processed and then stored in the data server. If the users want to review the data, the client APP might request polling data from the server with the flow chart as shown in Figure 5. When abnormity is found in the monitoring data, go to the stage of reverse control on the environmental parameters with the flow chart as shown in Figure 5.

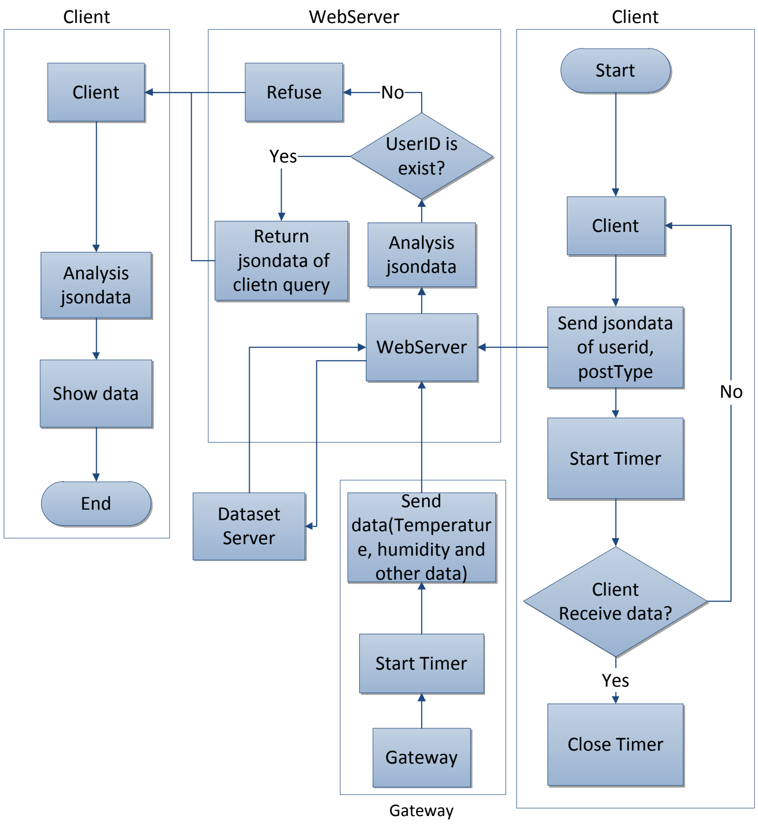

Figure 5. Flow Chart for the Query of the Farm Monitoring Data

Step1: The client APP will send a post request to the web server with the user information contained in the json request packet. After the web server receives the request, it will package the data into a json packet and return it to the client, where the package received by the client will be analyzed and loaded asynchronously.

Step2:Run the client APP in the polling mode to render the data acquired from the web server into a line graph.

Step3: Among the farm monitoring data that has been acquired, if some data is higher or lower than the preset threshold, such as extremely high or low temperature being detected, it will flow to the reverse control process.

Step4: In the stage of reverse control, first establish the connection between the client APP and the web server. Then send the node control command such as the temperature reduction command to the web server, where the command will be forwarded to the gateway to control the node devices for the reverse control operations.

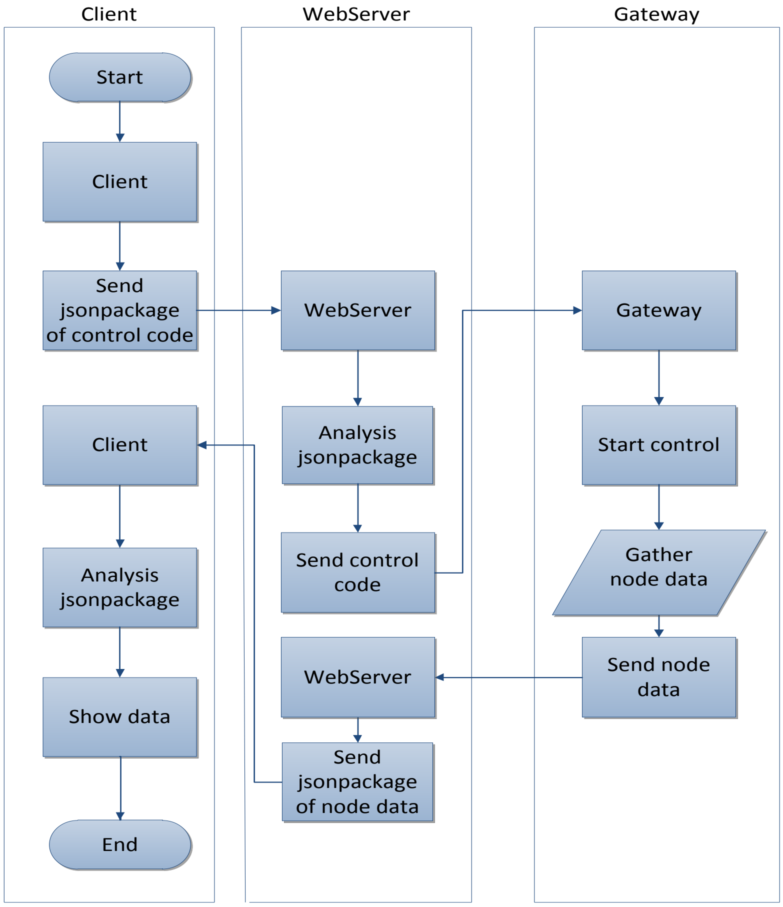

Figure 6. Flow Chart of Reverse Control

4. Experiment

On the basis of the internet of things-based rabbit farm environmental monitoring system proposed in this paper, a network layer consisting of a high-performance wireless Gigabit router and an HC-12 will be constructed. Two PCs installed with Windows Server 2008 will separately work as the web server and the data server with the application of the Android Studio 1.3[12] as the development tool for the Client APPs. The cell phone installed with an Android 4.2 system will be used as a test platform for the client APPs. The experimental results are shown in Figure 7.

The first image and the second image in Figure 7 show the interface where the Wifi password must be inputted and the barcode attached on the gateway must be scanned during the gateway initialization. The third, the fourth and the fifth images are the examples of temperature and environmental parameters, showing the real-time temperature data about the current rabbit farm through the client APP. The sixth image shows that the users will be provided with a prompt to enter into the reverse control interface for the temperature reduction operations when there's abnormity in the temperature parameters in the farming environment.

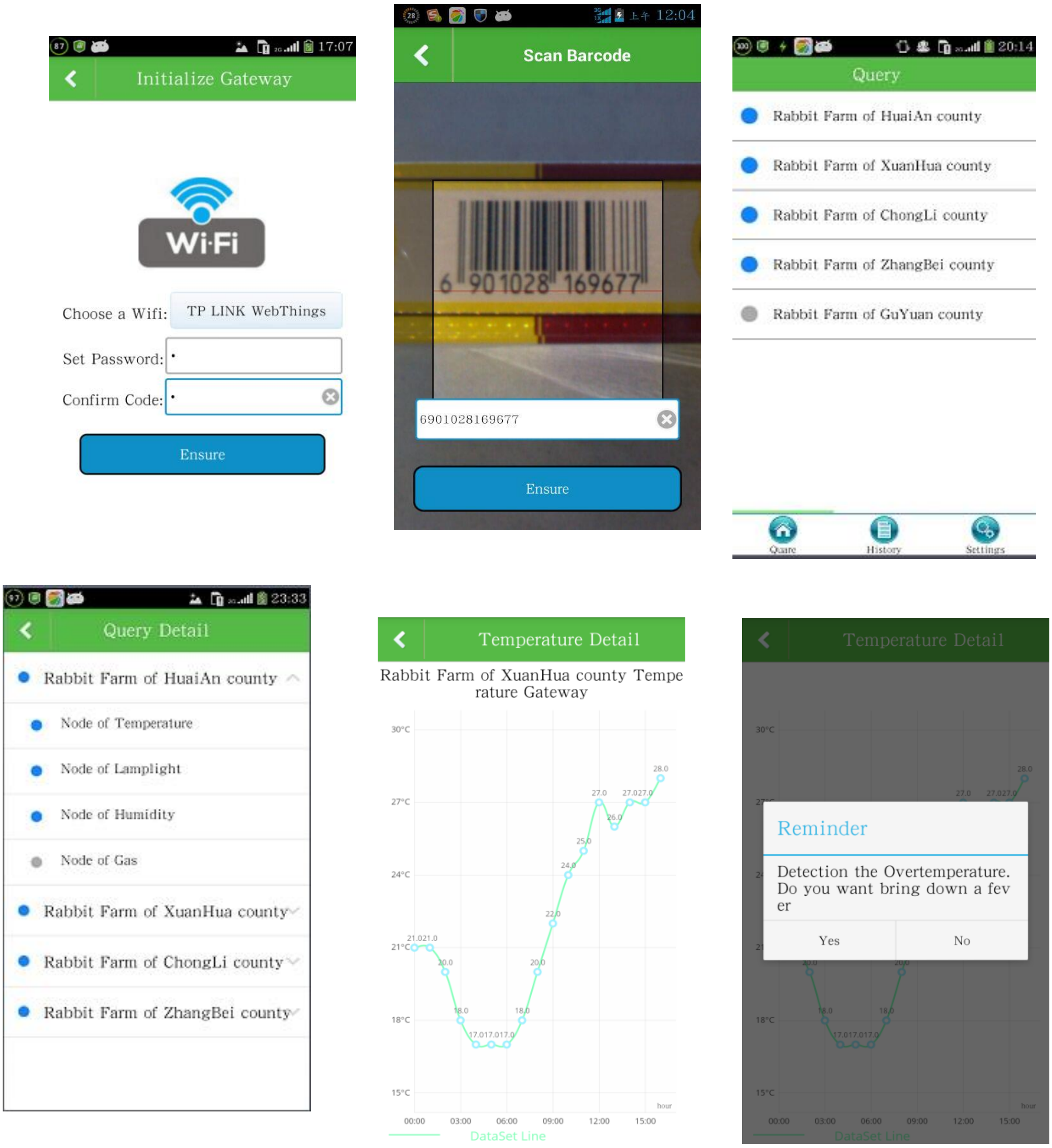

Figure 7. Experimental Results

5. Conclusion

This paper designs an internet of things-based rabbit farm environmental monitoring system. First, it proposes the overall architecture of the system and then makes a comparison on the advantages and the disadvantages of the common wireless transmission modules. On the basis of this, it chooses HC-12 as the wireless transmission module. After that, it solves the problems that have been found in the gateway of the internet of things during the gateway initialization in this system. Finally it analyzes the flow to query the environmental parameters in a rabbit farm and the flow for the directional control of the environmental parameters. It verifies the feasibility of the system through the experiment on the system functions. Moreover, with an open architecture, this system has strong expandability in the communication protocols and the software & hardware platform. On the basis of this, it would be very easy to develop such applications that are able to provide more functions for the internet of things.

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