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Design and Realization of Temperature Monitoring and Warning System Under Temperature Greenhouse

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Abstract: ZigBee technique is introduced in detail, and a temperature monitoring and warning system applied to temperature greenhouse is proposed on the basis of this technique. The system could send the greenhouse temperature monitored to central server through ZigBee gateway connected with the Internet, thus checking greenhouse temperature whenever and wherever possible. When greenhouse temperature is extremely high or low, it may give early warning to remind farmers to take timely measures on the greenhouse. And finally designing an experiment to verify the correctness of the technique is of strong practical value.

Keywords: Greenhouse temperature, temperature greenhouse, warning system, ZigBee.

1. INTRODUCTION

With the growth in the living standard, people's demands for fresh vegetables are greatly increasing. To increase vegetables production and quality, greenhouse technology becomes widespread, and the amount of greenhouse rapidly increases. Environment in the greenhouse directly influences crop growth, and greenhouse temperature is the biggest factor to have an impact on greenhouse environment. With too low a temperature, in less severe cases, the crops may stop growing, while in more severe cases, the crops may be frozen to death. With too high a temperature, crops may also die easily. Therefore, it seems very important to control the greenhouse temperature within an appropriate range [1]. With regards to traditional greenhouse temperature detection, thermometer may be placed at different positions in the greenhouse to measure greenhouse temperature through reading value of the thermometer. However, such a method is not only low efficiency, but it may also easily make mistakes, and after the greenhouse forms a certain scale, such manual test seems helpless. Therefore, some intelligent monitoring systems are introduced in modern greenhouses design. In Literature [2], an efficient and low-power-consumption wireless temperature collecting and storage system is designed, which may collect and store the temperature in the greenhouse, and it has some characteristics such as simple mechanism, easy control, strong anti-interference performance and good stability *etc*. In Literature [3], a kind of greenhouse temperature monitoring system taking the single chip as the core and established with CAN bus technology and temperature sensor, is designed. The system is with good commonality, and temperature control accuracy is high, anti-interference capability is strong, being able to meet the requirement for real-time measurement and control. In Literature [4], a kind of intelligent monitoring system taking single chip as the core is proposed, and the system has characteristics such as accurate monitoring, simple mechanism and stable performance *etc*. In addition, [5], a kind of temperature warning system is designed with single chip technology and adoption of temperature sensor, which can collect temperatures of multiple sensors, and is with advantages such as low consumption and intelligent regulation *etc*. In Literature [6], a kind of temperature detecting system based on digital temperature sensor DS18B20 and single chip is designed, and it has advantages such as wide temperature measurement range, high precision, easy control, being simple and practical, and real-time measurement to environment temperature *etc*. Technical proposals referred to in these references all could easily and accurately test the temperature in the greenhouse, but none of the proposals could realize to check the greenhouse temperature whenever and wherever. The system designed by the author can not only monitor greenhouse temperature whenever and wherever, but also gives warning.

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2. OVERVIEW OF ZIGBEE TECHNOLOGY [7-9]

ZigBee refers to low-power-consumption LAN protocol based on IEEE802.15.4 Standard. In accordance with international standards, ZigBee technology is a kind of short-distance and low-power-consumption wireless communication technology. ZigBee protocol respectively includes physical layer (PHY), media access control layer (MAC), transport layer (TL), network layer (NWK) and application layer (APL) *etc*. from the bottom up, and physical layer and media access control layer accord to regulations in IEEE 802.15.4 Standard. Characteristics include:

1) Low power consumption: Under low-power standby mode, 2 double A batteries may support 1 node under operation for 6~24 months, even longer. It is the prominent advantages of ZigBee. By comparison, Bluetooth may work for several weeks, and Wi-Fi may work for several hours.

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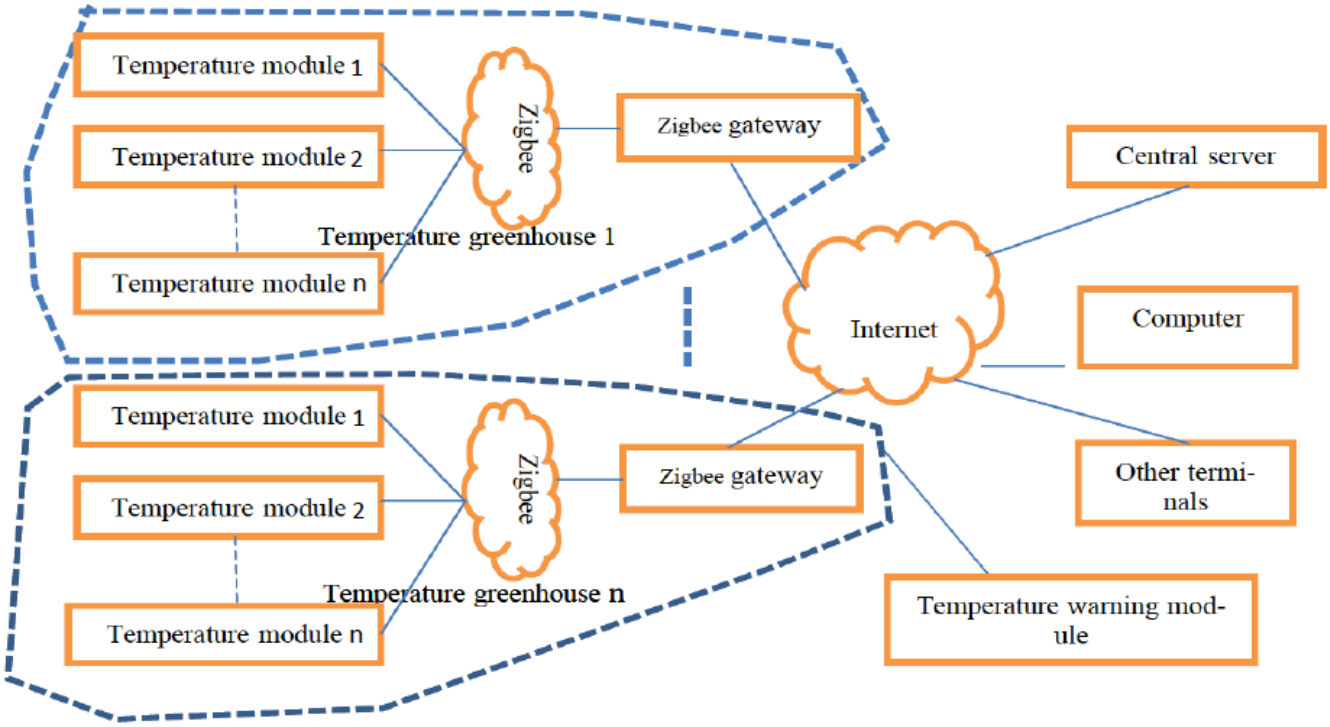

Fig. (1). Overall structure of the system.

2) Low cost: Through substantially simplifying protocol (not reaching 1/10 of Bluetooth), requirements on communication controller is lowered, and conduct analysis as per forecast, and make measurement with 8-bit microcontroller of 8051, main full-function node needs 32KB code, while subfunction node reduces to 4KB code, and ZigBee is free of protocol patent fee. The price of each chip is about 2 dollars.

3) Low rate: ZigBee works under rate of 20～250kbps, respectively provides original data throughput rate of 250 kbps (2.4GHz), 40kbps(915 MHz) and 20kbps(868 MHz), it may satisfy the application requirement of data transmission under low rate.

4) Close range: Generally transmission range is between 10 m and 100 m, after increase of transmittance power, the range may also increase to 1~3 km. It refers to the distance between adjacent nodes. Transmission distance will be much longer through communication relay between route and node.

5) Short delay: Response speed of ZigBee is fast, and generally it only takes 15 ms to switch from sleep to working condition, and it only needs 30 ms for connection of node to the network, further saving electric energy. By comparison, Bluetooth needs 3~10 s, while Wi-Fi needs 3 s.

6) High capacity: ZigBee can adopt starlike, sheet and mesh network structure, and has a main node controlling several child nodes, and one main node may at most control 254 child nodes; at the same time the main node may be controlled by upper-layer network node, and it may at most constitute a large net with 65,000 nodes.

3. SYSTEM DESIGN PROPOSAL

Overall structure chart of the system is as shown in Fig. (**1**), multiple temperature modules in each greenhouse are connected to ZigBee gateway through ZigBee, and then connected to Internet through gateway, finally realizing interconnection with central server, and computer terminal and other terminals can visit central server through Internet to acquire related data.

1) Temperature Module

Temperature module is mainly composed of single chip, temperature sensor and ZigBee module. And the temperature module runs a temperature detecting procedure to detect the temperature once every 20 s, and sends the data in real time to central server through ZigBee gateway. The central server takes charge of processing data, and the module has warning function on battery power. If the power is lower than the set threshold value, it may send warning data to the central server.

2) ZigBee Gateway

Taking charge of receiving data from temperature detecting module, and transmitting the data through Internet to the central server.

3) Central Server

The central server provides database service, and it takes charge of providing data operation to legal users, such as inquiry, deletion and setting *etc*. And in the meantime, it may provide Web service to make some terminals directly use the browser to check temperature in each greenhouse.

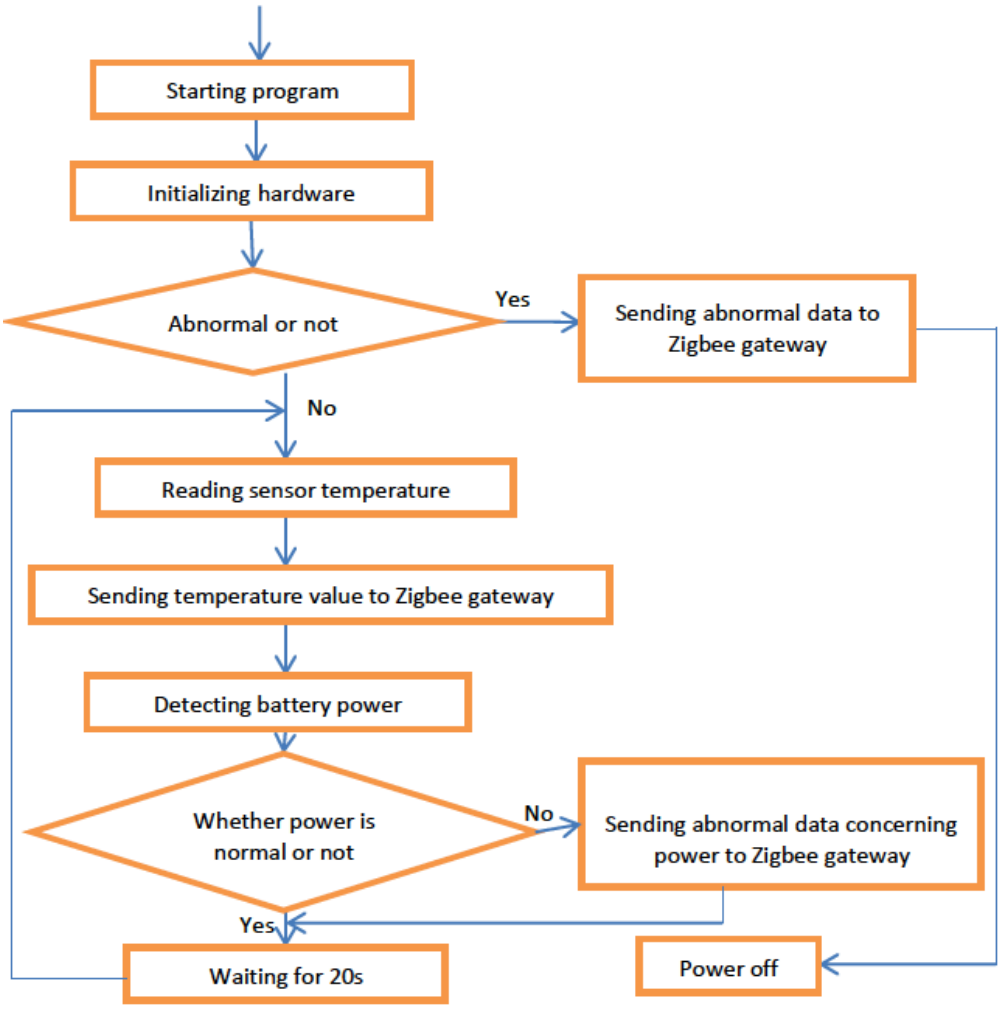

Fig. (2). Temperature detecting algorithm flow chart.

4) Temperature Warning Module

Temperature warning module is mainly composed of ARM processor and audible and visual alarm, and the module is generally placed in the monitoring room. Data are read from the central server each 10 s, and when the temperature in certain greenhouse is lower than safe temperature or higher than safe temperature, audible and visual alarm will start to remind monitoring personnel of the abnormal temperature in the greenhouse for timely treatment.

5) Computer and Other Terminals

Computer or other terminals (such as mobile phone and tablet *etc*.) may be used to visit central server through browser to check greenhouse temperature in real time.

4. TEMPERATURE DETECTION ALGORITHM

The algorithm mainly conducts temperature detection and battery power warning, and sending detected data information to ZigBee gateway. The flow chart of the algorithm is as shown in Fig. (**2**).

1) Hardware initialization mainly initializes sensor and ZigBee module *etc*.

2) During initialization, if the hardware is abnormal, the abnormal information will be sent to central server through ZigBee gateway, and then it may automatically power off.

3) Reading sensor temperature, and temperature values read are sent to ZigBee gateway.

4) Battery power detection. If the power is insufficient, it may send abnormal power information through ZigBee gateway to central server; and if the power is normal, directly go to step 5.

5) Wait for 20 s, and go to step 3.

5. TEMPERATURE WARNING ALGORITHM

Temperature warning algorithm runs on temperature warning module. When greenhouse temperature is lower than set temperature c1 or higher than set temperature c2, audible and visual alarm starts, and it may also start in case of insufficient battery power, and the audible and visual alarm may give out flickering light and makes a sound at the same time to remind monitoring personnel of the certain situation. Temperature warning module is generally placed in duty room or monitoring room. The flow chart of algorithm is as shown in Fig. (**3**).

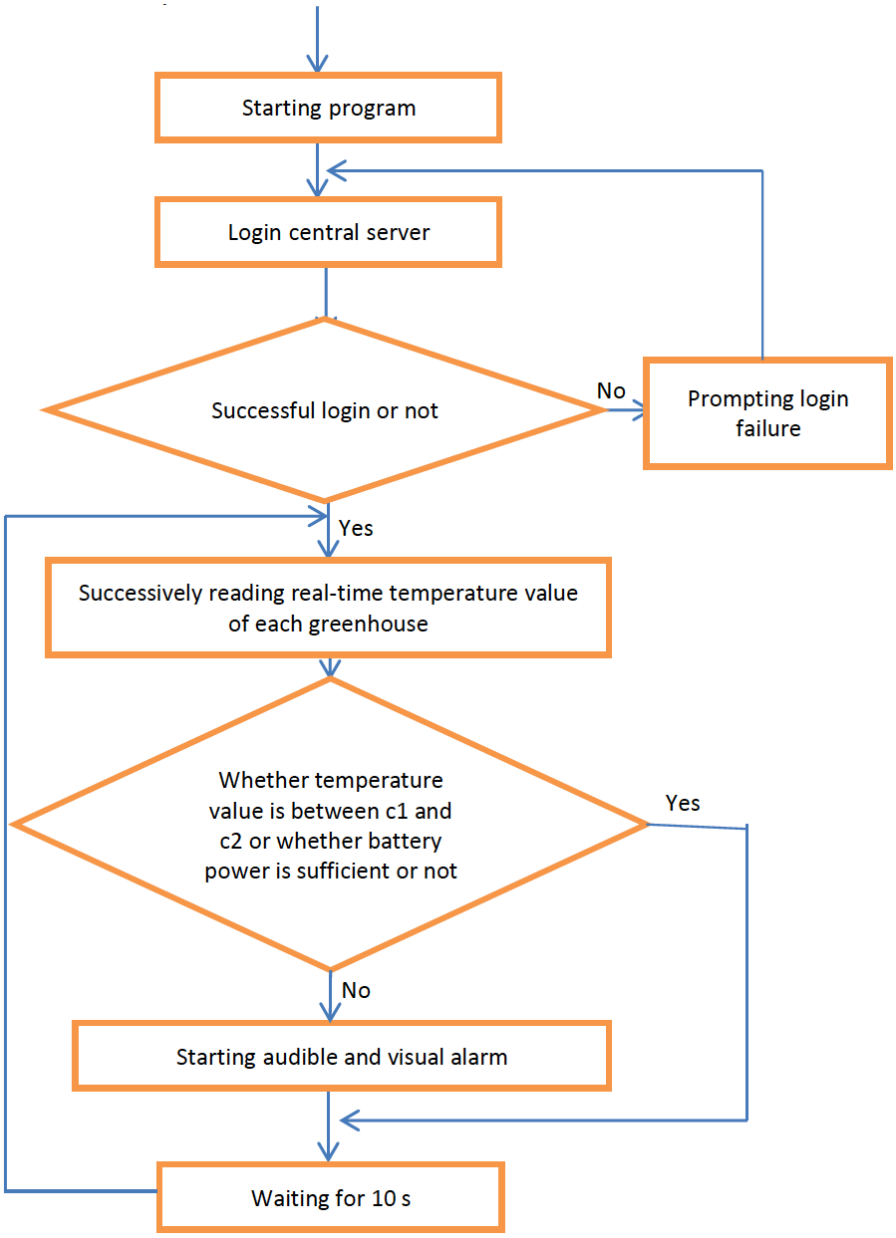

Fig. (3). Temperature warning algorithm flow chart.

1) Login central server by means of username and password. In case of failure of login, after related prompts are given, go to step 1, otherwise directly go to step 2.

2) Successively read temperature in each greenhouse, and battery power of each temperature module; judge whether temperature value is within the given range and whether the battery power is normal or not. If conditions are not satisfied, start audible and visual alarm, otherwise directly go to step 3.

3) Wait for 20 s, and go to step 1.

6. DESIGN OF EXPERIMENT

The experiment is conducted in an air-conditioned room of 5 m^2 with room temperature at about 6 ^oC, and place temperature sensing module and ZigBee gateway in the air-conditioned room. Additionally, ZigBee gateway is connected to local area network (LAN) through wireless router, and the central server. Warning module and computer terminals are all directly connected to such LAN through network cable, and the network topology is shown in Fig. (**4**). Take the following experimental steps:

In order to make the experiment effective, it needs to obviously set temperature threshold value within the range controlled by air conditioner, by setting temperature threshold value at 10 °C and 15 °C, and regulating indoor temperature through air conditioner. Open the air conditioner under heating mode, that is when the room temperature is higher than 20 °C, if audible and visual alarm starts, turn off the air conditioner to lower the room temperature. And when the temperature is lower than 10 °C, if audible and visual alarm starts again, it shows that the system design is correct.

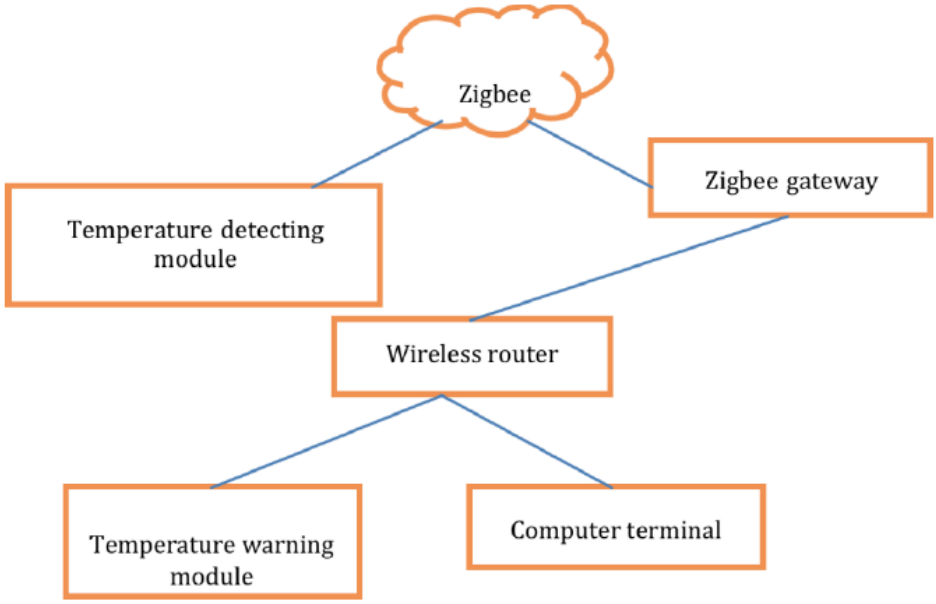

Fig. (4). Network topology.

CONCLUSION

In theory, it may connect up to 65000 temperature detection modules under each ZigBee gateway of the system, and there is no restriction on amount of ZigBee gateway. Theoretically, it may detect several thousand even over ten thousand greenhouse temperature, and the system can not only check current temperature of the greenhouse in real time whenever and wherever, but also give warning in case of too low or high temperature. The reachable distance of ZigBee network may be increased to 3000 m through increasing transmittance power, and it is applicable to large area agricultural production in controlled temperature greenhouses.

CONFLICT OF INTEREST

The authors confirm that this article content has no conflict of interest.

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