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Embedded Polyhouse
An Application of Wireless sensors & Fuzzy Logic

V. N. Gavande S. S. Bhabad

***Abstract*— Temperature, CO2, Light, PH of soil and humidity are important factors to the crops growth and product quality in greenhouse. The greenhouse monitoring system based on ZigBee wireless sensor networks (ZWSN) and fuzzy control is the best solution. The objectives of this paper are: (1) to develop ZWSN nodes for measuring Temperature,CO2, Light, PH of soil and humidity in greenhouse; (2) to program suitable software making the nodes sleepy without work for energy saving; and (3) to optimize network performance by setting a time delay for each nodes. Aiming at the actual demand of environmental information monitoring, green house CO2, temperature, humidity, light and soil moisture monitoring system based on fuzzy-PID strategy is designed. The system uses CC2430 as the core to develop wireless sensor nodes which follow the ZigBee communication protocol, uses the data collection terminal with high-precision CO2, temperature and humidity, light and soil moisture sensor to collect CO2, temperature and humidity light and soil moisture data of the environment, uses ZigBee technology to achieve networking of wireless sensors and the automatic aggregation of monitoring data, and uses the fuzzy PID control algorithm to improve the accuracy of test data. The regulation is achieved based on fuzzy PID control technology. The management function of various sensor nodes and a large number of environmental data is achieved based on embedded database.**

Keywords-Embedded Polyhouse, Wireless sensor networks, Zigbee, Fuzzy Logic

I. INTRODUCTION

The dynamic behavior of the greenhouse microclimate is a combination of physical processes involving energy transfer (radiation and heat) and mass balance (water vapor fluxes and CO2 concentration). These processes depend on the outlet environmental conditions, structure of the greenhouse, type and state of the crop, and on the effect of the control actuators The main ways of controlling the greenhouse climate are by using ventilation and heating to modify inside temperature and humidity conditions, shading and artificial light to change internal radiation, CO2 injection to influence photosynthesis, and fogging/misting for humidity enrichment. Crop growth is mainly influenced by the surrounding environmental climatic variables and by the amount of water and fertilizers supplied by irrigation. This is the main reason why a greenhouse is ideal for cultivation, since it constitutes a closed environment in which climatic and fertirigation variables can be controlled to allow an optimal growth and development of the crop. The climate and the fertiirrigation are two independent systems with different control problems. Empirically, the requirements of water and nutrients of different crop species are known and, in fact, the first automated systems were those that controlled these variables As the problem of greenhouse crop production is a complex issue, an extended simplification consists of supposing that plants receive the amount of water and fertilizers that they require at every moment. In this way, the problem is reduced to the control of crop growth as a function of climate environmental conditions.

A greenhouse carbon dioxide concentration measurement and control system is designed based on fuzzy control with infrared carbon dioxide gas sensor, and the choice of the control structure parameters are given. According to the experience, the main points of the design of control rules are induced, and the carbon dioxide concentration fuzzy controller is constructed with relevant fuzzy logic. The modular structure is used for system hardware and software design, enhance the versatility and flexibility of the use of system. The application shows that the carbon dioxide measurement and control system achieved using fuzzy control is running stable, fast response, has broad application prospects. The greenhouse is one of the typical representatives in facility agriculture. Its main advantages are off season cultivation, high yield, and strong resistance to adverse weather and soil conditions [1-3]. With the widely use of greenhouse, environment intelligent control technology is paid more and more attention in modern greenhouse. It regulates the temperature, air relative humidity and light intensity automatically so as to create the best growth condition and achieve off season cultivation. In recent researchers most control technology in greenhouse regulates the environment according to the data by a sensor located in the center of the greenhouse. It just considers the climate in the greenhouse as uniform, simply using the humiture at a point to represent the humiture in the whole greenhouse. ZigBee wireless sensor networks(ZWSN), a kind of short-range, low-rate wireless networking technology, solves the shortages of traditional greenhouse environment monitoring system and improves the performance of the whole system[6]. It has its own radio standards, realizing the thousands of tiny sensors to achieve mutual communication with very little requirement of energy. The self-configuring and self-healing nature of ZWSN makes deployment simple and ensures reliable communications no matter how the environment changes. It also provides

flexibility, allowing radio nodes and their associated controllers to be added, removed, or relocated without the need for traditional network cabling work. ZigBee technology has been widely used in industry, medicine, and military. Agricultural ZWSN has also become in an inevitable development direction. At present, ZWSN applications are still in the domestic of the experimental stage and did not develop a wireless sensor networks control system which is completed and suitable for greenhouse characteristics [7-9].The system used the ZWSN technology and designs multiple sensor nodes to collect the data of Temperature, CO2, Light, PH of soil and humidity inside a greenhouse. The performance of system and the battery life were major issues reliability. The humiture monitoring center develops with Visual BASIC programming language

II. COMPARISON OF WIRELESS COMMUNICATION PROTOCOLS

	ZIGBEE	Bluetooth	Wi_Fi	Home Rf
Frequency band	2.4Ghz/915MHz /865MHz	2.4GHz	2.4 GHz	2.4GHz
Modulation technique	BPSK	GFSK	QPSK	FSK
Maximum bit rate	250kb/s	1Mb/s	1Mb/s	1.6Mb/s
Power	low	Medium	High	Medium
Coverage area	100m	10	50	50
Network nodes	65000	8	50	127

III. SELECTION OF WIRELESS PROTOCOL

I selected ZIG Bee for wireless sensor communication, and also fuzzy PID controller for temperature and CO2 controlling and regulation. Aiming at the actual demand of environmental information monitoring, an indoor temperature and CO2 based on fuzzy-PID strategy is designed. The system uses CC2430 as the core to develop wireless sensor nodes which follow the Zig Bee communication protocol, uses the data collection terminal with high-precision Temperature, CO2, Light, PH of soil and humidity. Wireless sensors and the automatic aggregation of monitoring data, and uses the fuzzy PID control algorithm to improve the accuracy of test data. The temperature and CO2 regulation is achieved based on fuzzy PID control technology. The management function of various sensor nodes and a large number of environmental data is achieved based on embedded database. Transmission is easy to use, and can be widely used in various areas of automatic monitoring of environmental parameters.

IV. HARDWARE USED

The controlled objects, such as CO2, temperature, humidity, light and soil moisture in Greenhouse, have the characteristics of long delay and large inertia and so on. Through investigation and analysis, the applications of environmental monitoring system include the factors of environment are sampled and processed in real time in 24 hours and put into a database for the query, the sampled data are transmitted and aggregated in real-time by low-cost, low-power wireless communication in order to provide diagnosis, limit alarm function, the intuitive system management platform is provided to complete functions such as sensor management, environmental information processing, storage, and analysis and so on, information is processed on the basis of the detection, and control signals are formatted and output based on predetermined control strategy.

The greenhouse humiture monitoring system mainly consisted of ZWSN system and humiture monitoring center. Three types of network nodes set up the wireless sensor networks by a self-organizing mode: gateway node, router node, and end device node. Among them the end device nodes and router nodes managed the data collection of humiture inside greenhouse, and then the gathered data was sent to the gateway node, finally the gateway node sent data to the humiture monitoring center through serial port. In order to save costs, the tree-type network topology was used. The ZWSN used IEEE 802.15.4 (“ZigBee”) standard. ZigBee is an open specification, which is designed for the low power consumption, low rate and short distance wireless technology with lots of nodes. The core chip of network node selected CC2430 RF modules, and data acquisition sensors in router nodes and end device nodes selected temperature and humidity sensor DHT21, whose temperature measurement accuracy is ±0.5 and air relative humidity measurement accuracy, is ±5%. In view of DHT21’s 5 V supply voltage, DC-DC boost chip(S-1.2SY) is used to improve the output voltage of CC2430’s from 3.6V to 5V. The ZWSN software platform of CC2430/ ZigBee selects powerful IAR7.20H whose generated executable code is efficiency and manages data with database technology to realize data storage, data real-time display, historical data view and curve display of humiture monitoring center.

ZWSN includes two types of address: 16-bit network address and 64-bit physical addresses. When a network node joins in the network, its parent node assigns it a random 16-bit network address which isn’t assigned to other node. Once the node has been assigned a short address, it is no reason to give up the short address. The address should be retained unless it received a statement that the address conflicts with other node’s address. As is known to all, each network node has the unique 64-bit physical addresses which could be identified by user conveniently. Coordinator uses 0x0000 as its own 16-bit network address after establishing network. Router and end

device node achieve communication through 16-bit network address assigned by its parent node after successfully joining in network.

The deployment of sensor nodes is one of the key issues in the design of greenhouse ZWSN system. The number and location of the router nodes and end device nodes are properly optimize, by the premise of guarantee performance and monitoring on distribution characteristics of greenhouse environment ensures the communication of ZWSN excellent. Network node core board uses CC2430 chip, which is embedded an excellent performance 2.4GHzn RF transceiver together with an industry-standard enhanced 8051 MCU. 21 general I/O pins provide sufficient interface for peripheral devices. The CC2430 is highly suited for the systems where ultra low power consumption and high-performance are desired, especially in monitoring greenhouse temperature and humidity variations with a mass of nodes to avoid replacing battery. Three types of node are designed in this research including gateway node, router node and end device node. The gateway node is Full Function Device (FFD) to manage the communication among all network nodes and information interaction between wirelesses network and administration center as a coordinator. Router node is also FFD, which could transmit and receive both its own data and its neighbor nodes data, and form multiple redundant paths for communication importantly. End device node is designed as Reduce Function Device (RFD) to collect data and communicate with gateway node and router node. RFD internal circuitry is simpler than FFD and is conducive to reducing energy consumption [12-14]. The network has the intelligence to determine the optimal routing path, if necessary, that switch to another path while the original path is disrupted. The end device node collects temperature and humidity data, sending data to gateway node directly or by jumping the routers. For power saving the end device node can be turned on and off under software control. End device node is expected to spend most of their time sleeping, and work only when sampling, computing, and communicating, in order to optimize the system lifetime requirements. Minimizing power involves turning off sensors, the radio, and the processor to be put into a deep sleep mode. DHT21, a low power consumption and output digit signal calibrated temperature and humidity

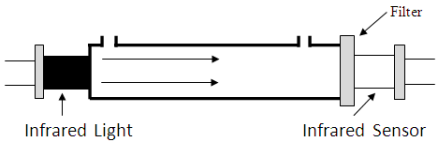

Figure 2. NDIR schematic diagram of infrared gas analysis

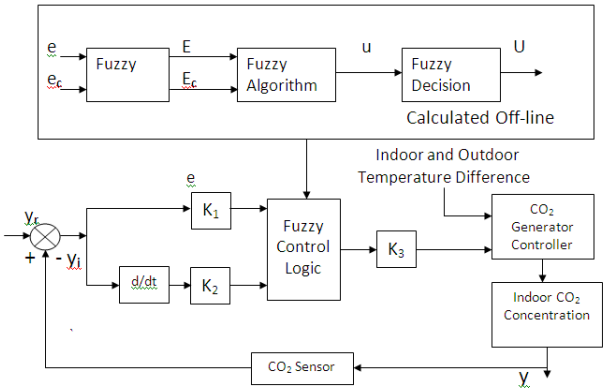

Figure 3. Schematic diagram of carbon dioxide concentration fuzzy

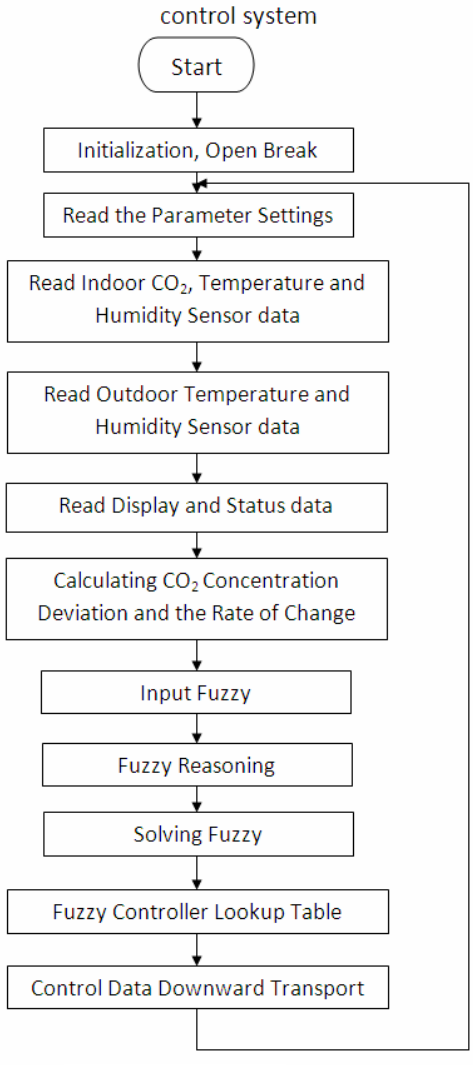

Fig. 4 System Flowchart

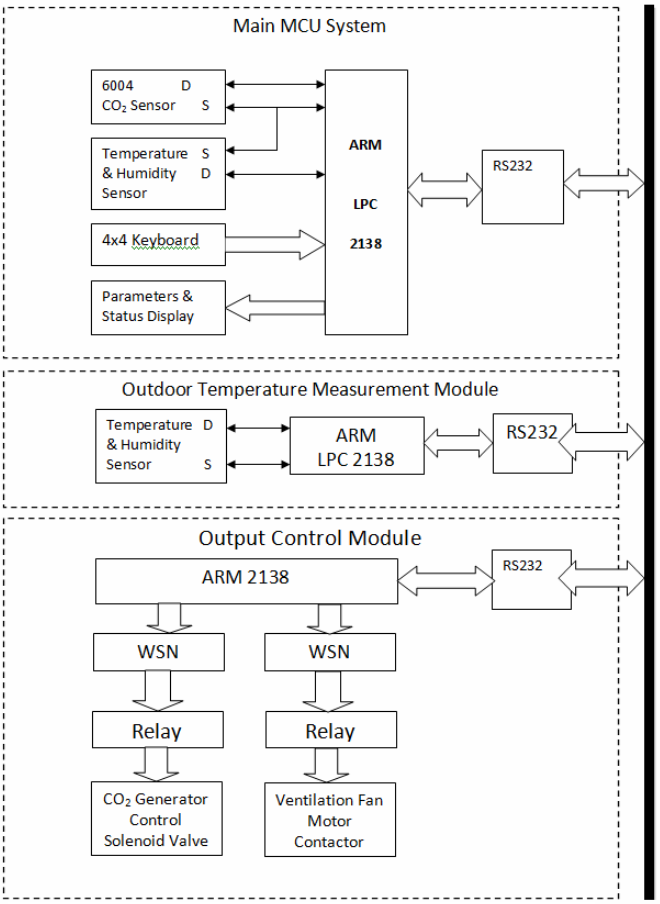

Figure1. Agricultural greenhouse carbon dioxide measurement and Control system hardware architecture

Conclusion:

ZWSN technology is used to build a greenhouse temperature and humidity monitoring system. ZigBee, which communicates in a tree-type network with low power radios, is reliable even in some very challenging environments. Barriers compared a traditional wired greenhouse monitoring system include the installation cost, difficulty, complexity, and budget cycles. The solution, ZWSN employs a self-configuring, self-healing ZigBee network enabling system to reduce the energy consumption efficiency while realizing data acquisition to overcome barriers of a traditional wired system. The node deployment, hardware design, and software design have completed. The performance of the system can be improved by setting a delay for each node at the beginning time of data acquisition. The method avoids the data packet jam and loss on delivery at the same time improving the data packet reception success rate

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AUTHOR PROFILE

V. N. Gavande

Student of ME (E&TC), Embedded & VLSI, K. K. Wagh I. E. E. R, Nashik, Maharashtra, India

E-mail : vishwas_gavande@rediffmail.com

Mrs. S. S. Bhabad

A. P. , E&TC Dept. K. K. Wagh I. E. E. R, Nashik Maharashtra, India

E-mail:ssbetlx@gmail.com