Research on water-saving irrigation automatic control system based on Internet of things

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***Abstract*—To improve irrigation water use efficiency, reduce cost of irrigation water, this paper discussed the design of wireless sensor network and Internet technology of farmland automatic irrigation control method.Emphasis on an analysis of the routing protocol of sensor network nodes to achieve the system hardware and software design,middleware, and applications such as mobile phone or wireless PDA of internet of things,will constitute a variety of sensors intelligent network, thus enhancing the overall automation system and monitoring levels.The final analysis of the network in the Internet based on the agricultural plants of farmland water-saving irrigation system integrated approach. User use mobile phones or wireless PDA can easily soil moisture content of online monitoring and control to realize the irrigation automation.Application results show that system through the embedded control technology complete intelligent irrigation, improve the agricultural irrigation water use efficiency and irrigation system automatization is generally low status, can well realize water saving.**

Keywords- water-saving irrigation ; wireless sensor; Internet of Things; routing protocol； localization of nodes

I. INTRODUCTION

As a new internet of things information network , for most types of agricultural materials, agricultural products through the Internet of Things will be fresh growth state, response to environmental changes, storage preservation, distribution and quality and safety of equipment, machinery, people close integration of active behavior, will have an important impact on the agricultural economy[1].

With the development of internet of things, its technology has been widely applied to all aspects of agricultural production, water-saving irrigation involves engineering, agriculture, biology, automation, communications, and many other technologies. water-saving irrigation automatic control system based on wireless sensor using the sensor and set the conditions and the receiver communication, control irrigation systems, valves open, close, so as to achieve the purpose of automatic water-saving irrigation. Because of sensor networks with multiple hops routing, information exchange recursion, self-organizing networks and network communication time synchronization characteristics and irrigation area, the number of node can not restricted, and thus can be flexible increase or decrease round irrigation group. And nodes with soil, plants, weather measurement acquisition device that uses communications gateway Internet functions and GPS techniques combined to form the dynamic management information collection and analysis irrigation technologies, along with crop water information collection and semi-precise control irrigation technique, expert system technology, etc., can construct high efficiency, low power consumption, low investment, multi-function agricultural water-saving irrigation platform[2]. Users can also in a greenhouse, courtyard garden green, the central isolation belt highway, agricultural wells and other areas with irrigated areas, agricultural and ecological water-saving technology, quantification, standardization, modeling, integration, and promote the rapid and water-saving agriculture healthy development.

Automatic irrigation control system has the following advantages:

1, will give full play to the role of the existing water-saving devices, optimal operation and improve efficiency.

2, through the application of automatic control technology, more water and energy conservation, reduce irrigation costs and improve the quality of irrigation.

3, will irrigate more scientific, to facilitate and improve the management level.

Control the development and promotion of water-saving irrigation technology is the need for agricultural modernization.

II. EXISTING RESEARCH RESULTS

In the internet of things related techniques, domestic currently in wireless sensor network software made corresponding breakthrough on the operating system based on foreign to develop their own middleware software. Such as the Nanjing University of Posts and Telecommunications research center for development of wireless sensor networks based on mobile agent middleware platform for wireless sensor networks, shenglian technology development of wireless sensor network development kits. Domestic research institutions in the theoretical research, such as network protocols for wireless sensor networks, algorithms, architecture, etc., put forward a number of innovative ideas and theories. In this field, Nanjing University of posts and telecommunications, Tsinghua University, Beijing University of Posts and so made some relevant theoretical research results[3].

In other countries, many American universities in the wireless sensor network has carried out a lot of work. Such as

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the University of California, Los Angeles, CENS (Center for Embedded Networked Sensing) Laboratory, WINS (Wireless Integrated Network Sensors) Laboratory and IRL (Internet Research Lab) and so on[4].

This paper reference some enterprise's actual production processes, from home and abroad to the traceability system related research, through research based on internet of things water-saving irrigation system scheme, the original traceability system based on Web water-saving irrigation processing scheme must be improved and in practical projects application and achieved good effect.

III. DESIGN OF WATER-SAVING IRRIGATION AUTOMATIC CONTROL SYSTEM

A. wireless sensor networks

Wireless sensor network technology applied to the water system, its core technology is the application of ZigBee networking technology since. ZigBee is a low heterogeneous, low power, low data rate, low capital, high-solid reliability, a large network capacity two-way wireless communications technology[5]. By using the layer, network layer, medium access control layer and physical layer. Based on ZigBee wireless sensor networks system can solve the cable transmission bring cost is exorbitant, cabling complex, maintenance trouble, flexibility and expansibility such a series of problems, which saves the human resources, went to the lavatory again information management, has been used steel temperature monitoring, vegetable shed steelmaking temperature, humidity and soil ph monitoring, gas meter and other fields, it is the realization of the system provides a better solution.

B. system architecture design

The system uses singlechip control center, by wireless sensor node (RFD), wireless router nodes (FFD), wireless gateway (FFD), the monitoring center four local composition, accepted the ZigBee since network, the monitoring center, wireless gateway between resolution GPRS hold moisture content and control information transfer. Each sensor node resolved temperature and humidity sensors, soil moisture information automatically collected and combined upper and lower limits of humidity at the default analysis, determine what can and can not have irrigation hour suspension. Each node with a solar battery, the battery voltage is monitored at any time, once the voltage is too low, the node will issue a low voltage alarm signal sent successfully, the node into the sleep pattern until it is fully charged. Autonomous sensor nodes and routing nodes form a multi-hop network. Monitoring of temperature and humidity sensors distributed in the region, the collected data sent to the nearest wireless routing node, the routing node routing algorithm based on selecting the best route, and establish the appropriate routing list, which list contains the information itself, and the neighbor gateway information. Protocol gateway send data to remote monitoring center, convenient for the user to remote monitoring maintenance. Water-saving irrigation automatic control system based on the Internet of Things shown in figure 1

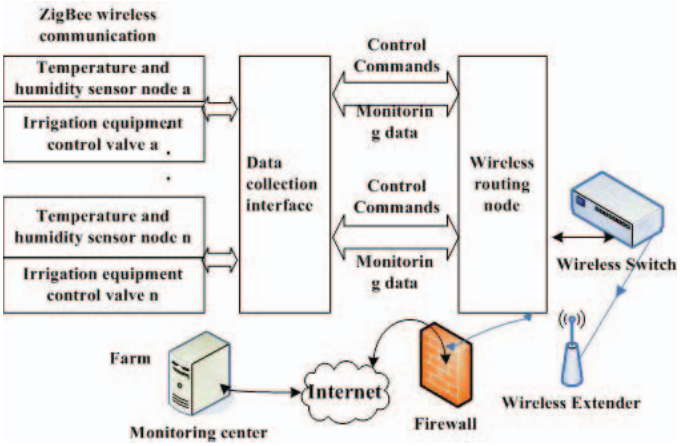

Figure 1. Water-saving irrigation system structure

C. system hardware design

Main achievement of the system sensor nodes monitoring soil water content, EC (conductivity) value and the PH value of the monitoring, monitoring of the state of the solenoid valve, solenoid valve to control the state, various monitoring and control of transmission of communication signals and low voltage alarm. Each control unit controls the 1-6 way solenoid valve. Through the sensors to collect to of multi-channel data, after A/D conversion, signal processing, in microprocessor, according to different vegetation needs, identifying water amount, then control signal output, combining central management of A computer instruction, control the solenoid switch, namely can achieve automatic irrigation. Soil moisture sensor used to measure the soil moisture, in order to understand the real irrigation, soil basis, determined irrigation or not and duration, equipped with EC value and PH sensors, may to the inlet and outlet water for EC value and pH value detection, in order to control automatically nutrient rationing. The main block diagram shown in Figure 2.

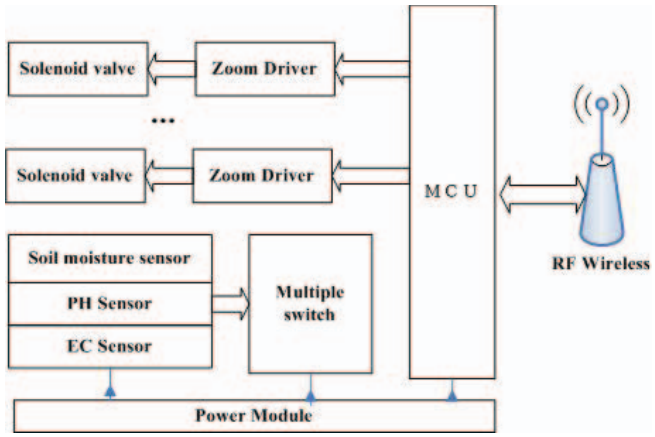

Figure 2. Sensor nodes hardware control structure

D. system software design

The system uses Internet environment, the use of B/S model for development. system server operation system chooses Linux, the main technology used for the Java EE and Java programming language, database system used Oracle11g. Real-time data processing system database is the core of the

whole. Real-time database as an intermediary link, the data situation in order to realize the scene is reflected in the form of animation on the screen, making the operator's instructions before the computer can quickly reach the scene. Software structure shown in Figure 3.

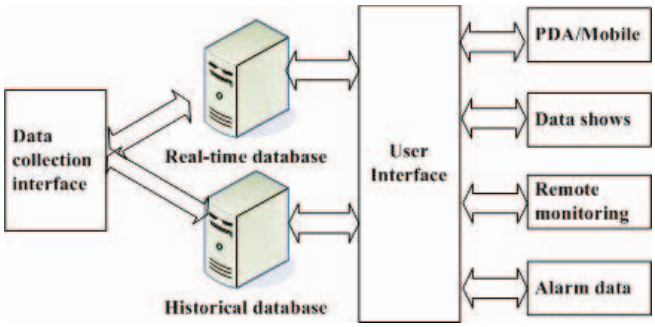

Figure 3. Structureof software

IV. IMPLEMENTATION OF WATER-SAVING IRRIGATION AUTOMATIC CONTROL SYSTEM

A. design of sensor data processing middleware

Data acquisition and control function, can pass hardware driver and equipment communication, complete data acquisition and control tasks, sensor middleware function modules should contain the following several function module:Reader interface module, the logical drive mapping module, sensors data filtering module, the business rules, filter modules, equipment management and configuration module, the upper service interface module [6-7]. And, Reader interface for middleware and sensors reader data communications, mainly to have access to sensors data and device management module to issue commands reader. Equipment management configuration module is used to adjust the working status of sensors read-write device, configure the appropriate interface parameters such as Reader, logical reader will be more physical mapping module reader for the reader or multiple antennas into a logical map reader.

Control procedures and parameter Settings by sensor data processing middleware provided in the programming language scripts in writing.

B. Sensor network routing algorithm

Routing protocol to solve the data transmission problem, which is the core technology of wireless sensor networks and the key technologies to ensure network performance. Since wireless sensor network node capacity constraints, the traditional IP network routing protocols are generally not suitable for wireless sensor networks [8-9]. Wireless communication network of the traditional focus on wireless communications service quality (Qos) on the [10-13], while the

Clustering routing protocol should be LEACH, LEACH is the first cluster based on multi-cluster structure of the routing protocol, compared with the traditional protocol, which can better save energy. LEACH's cluster approach through its many levels, after the proposed routing protocol, then a lot of clustering routing protocols (such as TEEN, PEGASIS) are developed on its basis, its results also apply to many other routing protocol. Therefore, this section on the main research and discussion on the LEACH protoco[14-16].

Due to the middle of wireless sensor network by the design of first consideration is energy problem, it is necessary to study channel energy loss model. Different communication characteristics, we will have different energy consumption model. Channel energy model with free-space propagation model and multiple attenuation model two. If the receiving node and the distance between the sending node is less than some critical value d_0, free space model is used; otherwise, the use of multiple attenuation model. Critical value d_0 is defined as follows:

$$d_0 = \frac{4\pi\sqrt{ah_r}h_t}{\lambda} \qquad (1)$$

Where, α is the path loss exponent, h_r is the receiver antenna height, h_t is the height of transmitting antenna, λ is the wavelength of the signal.When the sending node k bit data to the associated transmission distance d of the receiving node, by the following formula to calculate energy consumption of transmitting nodes

$$E_{Tx}(k,d) = E_{Tx-elec}(k) + E_{Tx-amp}(k,d)$$

$$= \begin{cases} E_{elec}\times k + \varepsilon_{fs}\times k\times d^2, d < d_0 \\ E_{elec}\times k + \varepsilon_{mp}\times k\times d^4, d \geq d_0 \end{cases} \qquad (2)$$

Loss of signal strength and transmission distances related. When the transmission distance is relatively close, the use of free-space propagation model, path loss exponent of 2, when the transmission distance is relatively far, the use of multiple attenuation model, path loss exponent is 4[17-18].

Where, $E_{Tx-elec}(k)$ is the emission k bit data transmitter circuit energy consumption, $E_{Tx-amp}(k,d)$ is the emission k bit data transmission distance d and the energy consumption when the power amplifier. E_{elec} bit of data for each circuit in the transmitting or receiving the energy consumed by the circuit. Constants ε_{fs} and ε_{mp} and the transmission channel model used is related to a free space transmission of the ε_{fs}, multi-path fading transmission of the ε_{mp}.

All nodes LEACH self-organization cluster in clusters, by a node as cluster head, all cluster member node sent to cluster head, cluster head of data fusion processing backwardness to base station. Cluster head than cluster nodes consumes more energy members. Therefore, in the LEACH routing protocol, using a random rotation of cluster head node mechanism to avoid depletion of energy.

a) proportion of stages cluster head

Clusters in the first network to establish the time, to elect the current round of the cluster head node. Specifically, each

node in the 0 to 1 to select a random number, if the random number than the predetermined threshold T (n) is small, then the node for the cluster head in the current round; otherwise, in the current round of the cluster members.

b) the organizational phase of clustering

This stage, each node must determine if they should act as the first round of the cluster nodes. Determine the cluster head immediately after the broadcast packet to the network, the information package contains the node's own ID. Each node according to the received signal strength, choose the source node sending the strongest signal as their cluster head node. Once the decision as to which cluster node after the node through the carrier sense multiple access (CSMA, Carrier-Sense MultipleAccess) MAC protocol that information to the cluster head, cluster head node notify its members that he would become one of information includes its own ID and the cluster head node ID.

c) the organizational stage cluster creation Timetable

Cluster head according to oneself the number of cluster nodes in creating a time table, and through broadcast announcement each cluster nodes in the data transfer time. Using time buttress table can make cluster member node data transmission won't collisions and conflicts, and in the data transmission period, node can shut down their wireless device, will it be more energy saving. So far, the stage of establishing a cluster finish, began to stabilize the data transmission phase.

V. PERFORMANCE TESTS

In order to verify the improved performance of routing protocols, made by computer simulation of the algorithm. Simulation network model used is:

(1) assumes network CPC have 200 sensor node, each node of the initial energy set to 0.20 J.

(2) Network for the 60m × 40m square area, the base station is located in the center of the entire network area.

(3) Assuming the position of the nodes in the network information is known.

Channel energy loss model parameters shown in table 1, the network energy consumption, as shown in figure 4 shown abscissa denotes said Internet working a number of rounds, y-coordinate means that the current round of network operation in total energy consumption of energy, the unit is joule. Client data display interface figure 6 below.

TABLE I

ENERGY LOSS CHANNEL MODEL PARAMETERS

Parameter entry	*Parameter values*
E_{elec}	60nj / bit
ε_{fs}	100pj/bit/m^2
ε_{mp}	0.0013pj/bit/m^4

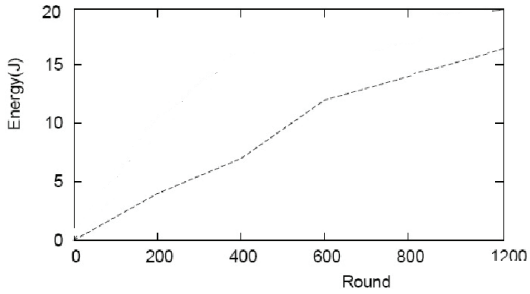

Figure 4 Energy consumption of sensor network algorithms network

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