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On the embedded intelligent remote monitoring and control system of workshop based on wireless sensor networks

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Abstract: The embedded intelligent remote monitoring and control system of workshop based on wireless sensor networks sets the sensor technology, embedded technology, network communication technology, data processing technology, Beidou positioning technology, sensing information technology of image and weather, geographic information technology and remote sensing technology in one, forming a digital information management system that can provide a full range of electronic remote monitoring and control for the workshop. Its wireless sensor network is a self-organizing network that is constructed from a large number of sensor nodes, which sets such three technologies of sensor, micro-electromechanical system and network in one, taking the perception, collection and processing of the information of the perceive objects in the network coverage as its aim and transfering it to data processing center to provide a basis for the remote monitoring and control of the workshop. This embedded intelligent remote monitoring and control system of workshop has many advantages: high safety, low cost, intelligence, timely alarm, energy conservation, good real-time control, wide monitoring range, strong adaptability, and so on. This monitoring system can be applied to not only plant monitoring but also other fields, such as environmental monitoring, industrial control, intelligent city, intelligent home, etc, so it has important practical significance and valuable practical value for exerting network advantage and making artificial intelligence promote social progress.

Keywords: Embedded, Wireless Sensor Networks, Remote Monitoring and Control, Beidou Positioning System, Microprocessor, Wireless Communication

The recent years' emergence of wireless sensor network has become a frontier international multidisciplinary research hotspot. This wireless sensor network consists of several single points with computing, wireless communication, sensing or control capability and has several functions such as signal acquisition, real-time monitoring, Information transmission, collaborative processing, information service and etc. [1] It expands network technology and realizes the real-time monitoring of environmental conditions and facilities. Becoming the core of the internet of things, sensor network is mainly used in the senor layer of the internet of things and for the purpose of tracking, monitoring, decision-making support.

Embedded System refers to a specialized computer application system based on the computer technology, with hardware and software portability and strict requirements for reliability, cost, volume, power consumption and other functions. Embedded system consists of hardware and software. Hardware includes embedded microprocessor and peripheral equipments; while the software includes embedded operating system and specific application programs. The embedded technology is widely used intelligent control, monitoring and management.

Measurement and Control Technology refers to the monitoring and control of the characteristics of a certain thing. [2] Remote Control refers that measurement and control personnel uses computer network connects controlled equipments through remote of computer such as the equipment inquiry, configuration, modification and etc. It can realize the seamless connection between office automation and industrial automation. Through B/S model, clients only need to install a web browser to download the program from the web server to achieve installation and operation so as to realize remote measurement and control.

The rapid development of computer, communication and microelectronics technology result huge changes in the field of measurement and control system. Networking and informationization have become the developmental

direction of measurement and control technology. Sensor network, embedded technology, and comprehensive utilization of industrial measurement and control system technology realize Web-based remote measurement and control system, which greatly improves the real-time, security, maintainability of measurement and control, strengthens the centralized monitoring and unified scheduling and management optimization. What author researches in this article is a web-based embedded intelligent workshop remote measurement and control system through which successfully designs and realizes intelligent home furnishing systems.

1. The Overall Structure of Embedded Intelligent Workshop Remote Measurement and Control System

Embedded intelligent workshop remote measurement and control system mainly consists of three parts: the embedded measurement and control unit, local server, remote management mainframe computer. The basic architecture of the remote measurement and control system is shown in Figure 1.

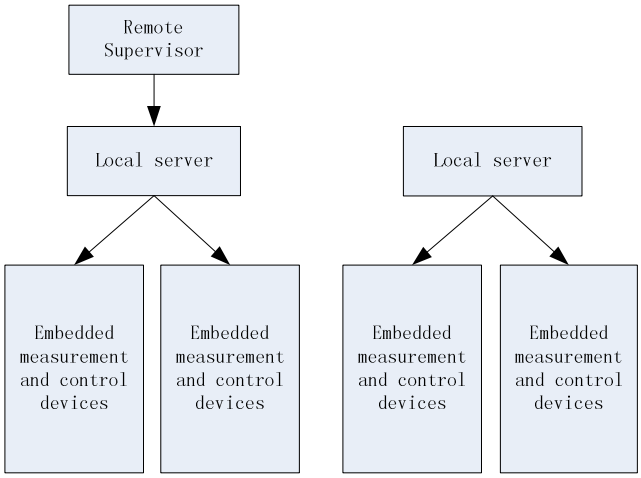

Figure 1: *The basic framework of embedded intelligent workshop remote measurement and control system [3]*

The embedded measurement and control units at the bottom layer are mainly distributed in the measurement and control node points including the central processor, sensor, actuator, network interface, BDS module, GPRS module, which is mainly for environmental parameter acquisition in workshop and then compared with set point. When the set value range is exceeded, the system alarm immediately alerts and starts the actuator to obtain the normal parameters and simultaneously transfer the testing date to the local server through local protocol for manager display. The BDS module can clearly position the faulted equipment. As wireless transceiver module, GPRS module can transmit data with high quality and realizes the realistic feasibility of the application of embedded system in remote measurement and control system.

As a middle bridge, the local server not only needs to receive monitoring parameters uploaded by measurement and control units, but also save them to the database, regularly makes inquiries and analyze the status of measurement and control units. If error is found, clients will be immediately notified with short messages. At the same time, the server will regularly feedback the date of database to remote manager in order to let clients timely monitor the status of measurement and control equipments and let manager realize the control on measurement and control equipments.

Placed on the top layer, Remote Manager can analyze inquiry and manage measurement and control units, receive all kinds of information uploaded from the measurement and control server. It can send order to control and deal with each measurement and control unit at the bottom layer in accordance with IP address to achieve a unified management of equipments. System implements wireless connection operation through GPRS, and users can achieve real-time control on them at any time.

Embedded intelligent workshop remote measurement and control system collects the parameters of each node through pre-sensor module and information receiving module and sends them to the embedded system for storage and processing, and simultaneously transmits the monitored information to the measurement and control server through which displays it on the manager so as to achieve the control of the measurement and control equipment. This embedded intelligent remote measurement and control system can link a small device to the Internet and timely monitor the operation of each device. The network monitoring is more flexible with relatively low cost for construction and maintenance and it can save large amounts of data with data storage methods and high system integration. It breaks time and geographical constraints. As long as network is available and user is authorized, the measurement and control task can freely accord with needs and achieve plug-and-play.

2. The Key Technologies of Embedded Intelligent Workshop Remote Measurement and Control System

2.1. Embedded System Design

The measurement and control equipment unit of embedded intelligent workshop remote measurement and control system equals each node point of wireless sensor network for information collection, transferring optical signal, chemical signals and other signals into electrical signals, and transmitting them to the microcontroller for processing. The measurement and control equipment of embedded intelligent workshop remote measurement and control system is an intelligent measurement and control system by using the R&D of embedded technology, and the

core of which is central microprocessor, equipped with SDRAM, NAND FLASH, RJ-45 network interface, 4 lines of touch screen interface, serial interface, LCD, USB interface, SD memory card interface, A/D and D/A converter. Through SP3243ECA chip with UART1 and UART2, the TTL level is changed into RS232 level, which realizes the information exchange between BDS and GPRS. The hardware structure of embedded intelligent workshop remote measurement and control system is shown in Figure 2.

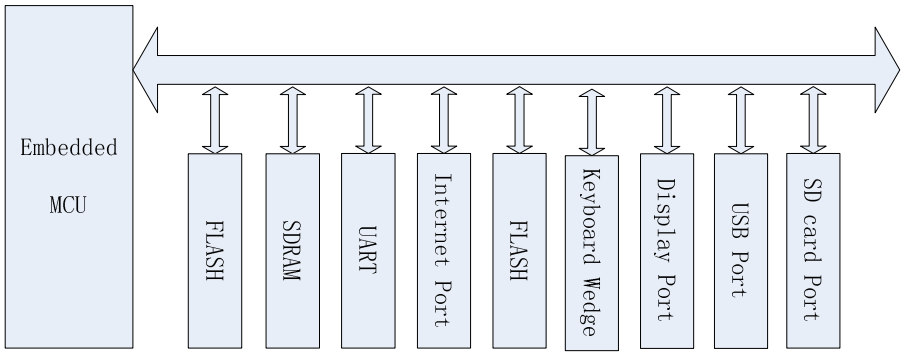

Figure 2: *The hardware structure of embedded intelligent workshop remote measurement and control system [3]*

The software of embedded intelligent workshop remote measurement and control system mainly includes startup programs, drivers, operating system, application program and etc. The open source code of Linux operating system can tailor kernel and operate on the hardware platforms like ARM with high efficiency [3], which has an advantage of equipping powerful network functions and excellent file system support functions. Therefore, we can use the Linux operating system. After the procedure of tailoring and cross compiler, an ARM executable file is formed and then it will be downloaded to FLASH through serial and network port. The application program of measurement and control system mainly includes data acquisition module, LCD module, keyboard control module, network service module, communication service module, control execution module and etc. In order to construct a better human-computer interface, we can transplant the QT/Embedded graphical user interface support system to the Linux [4] to develop appropriate graphical user interface.

2.2. Web Application Technology

The embedded intelligent workshop remote measurement and control system adopts B/S model. In order to directly access to the intelligent measurement and control equipment unit from the measurement and control server or measurement and control manager, it is possible to install a server with web browsing function on the intelligent measurement and control equipment unit. Here, we adopt Boa as web server on the Linux platform, which will be convenient for system stability and efficient operation in the target system, and or use and maintenance with high reliability. Boa and a normal web server share similarity in the capability of receiving the request from clients, analyzing request, responding to request, and returning the result of request to client and other tasks. The difference between Boa and normal web server is that the HTTP request for processing of Boa enjoys high speed and efficiency, and therefore it will have a high value in the application in the embedded system.

The main steps of Boa program transplantation are shown as follows: (1) Downloading Boa source code for ARM-Linux and Unzipping it (2) Generating and modifying Makefile file, and changing CC=gcc to CC=/usr/local/arm/2.95.3/bin arm-linux-gcc, and CPP=gcc-E to CPP=/usr/local/arm/2.95.3/bin/ arm-linux-gcc-E; (3) The binary file compiled by Boa server will be downloaded to the FLASH, and then web server will have its functions. [5]

2.3. Data Communication Technology

The communication equipment of embedded intelligent workshop remote measurement and control system mainly includes wireless network, BDS, GPRS and custom protocol communication and etc.

The selected date of this communication system design is transmitted and collected through the MC35 of GPRS module produced by the subsidiary of Siemens. The MC35 module supports GSM900 and GSM1800, a dual-band network, with a receiving rate of 86.20Kb/s, sending rate of 21.5Kb/s, and it is easy to be integrated. Through TTL232 level, it is converted and connected with the interface of UART1 of ARM2440 processor.[3]

The communication system design adopts GPS and Beidou Double-Star, a dual-mode navigation positioning technology that can position the intelligent measurement and control equipment units, researched and developed by China. The system uses Beidou Double-Star terminal to achieve fast positioning, and transmits the position information to the central station through GSM and Double-Star short message to user to achieve zoom alarm. The Beidou Double-Star Positioning System can not only achieve fast positioning to provide users all-weather, real-time positioning service with an positioning accuracy equivalent to GPS, a short message transmitting 120 Chinese characters information; and accuracy timing that can reach an accuracy of 20ns.

The communication of intelligent measurement and control equipment units, local server, and remote manger is realized through TCP/IP protocols. Due to limited resources of embedded systems and huge quantity of TCP/IP protocols, reasonable tailoring of TCP/IP protocols is particularly important. The simplification of TCP/IP protocols should follow two principles: Firstly, the characteristics of connection oriented cannot be changed; secondly, the simplification should fit the applied protocols at the application layer. [6] Local server and remote manager realize the communication with intelligent measurement and control equipment units through its dynamic web pages. Then, the receiving and sending orders are realized.

3. The Application of Embedded Intelligent Workshop Remote Measurement and Control System

With the development of sensing technology, semiconductor technology and embedded technology [7], wireless sensor networks have obtain rapid development and research results. Its application expends from single military field to diversified fields, such as environment monitoring, industrial control, intelligent city, intelligent home furnishing and other fields where practical results are received. [3] What the author describes here is an intelligent workshop remote measurement and control system platform based on sensor network and ARM in order to achieve monitoring and control on the fire alarm, rainwater parameters and other equipment. The personnel for monitoring and measuring can remotely control the equipment scatted in different positions with no need to go to the scene.

3.1. Selection and Design of Embedded Measurement and Control Equipment Unit

The embedded intelligent workshop remote measurement and control equipment units are allocated in the different positions within the workshop to collect the information of workshop site information, and to control them. The information collected mainly includes workshop temperature, humidity, smoke, carbon dioxide, other environmental factors and the electrical states of the work. And the system should measure and control these parameters and realize the communication of the whole network as well as the display function of the web server.

The wireless network of embedded measurement and control system is mainly used to measure temperature, humidity and smoke. The humidity sensor is installed on the switch of the window to control it based on the collected humidity information such as whether it rains. Here we use HM1500[8] as the humidity acquisition unit because its humidity measurement range is 0%~100% with a relatively wide range. Also it works well even if soaked, depends little on temperature and has good linearity. Integration of temperature sensor and air conditioning can achieve automatic temperature control; fire measurement sensor uses NIS-09C[9] because it has a function of high sensitivity in smoke detection and a fire alarm function.

When the measurement and control system detects that the workshop humidity is higher than the prescribed range, the actuator will close the window; otherwise, there will be no operation. When the detected temperature is higher or lower than the specified temperature range, air conditioning will be started automatically to adjust the temperature of the workshop; when smoke is detected, switches of the extinguishers and windows will be controlled and the alarm will be alerted, the monitoring and measuring personnel will be notified by short messages to effectively deal with the fire.

The remote control switch of measurement and control system is functionalized through a control circuit. The remote control circuit for apparatus is shown in Figure 3:

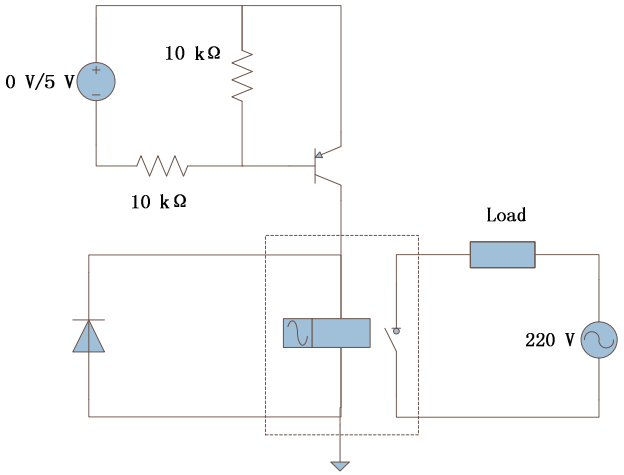

Figure 3: *the control circuit of [3] with remote control electrical appliance switch embedded intelligent measurement and control system*

The output signal of the microcontroller of the embedded intelligent measurement and control system will be functioned as the input signal of relay after driven by transistors. If the output of the microcontroller is low level, the transistor will reach saturation and it will energize the relay for actuation and load will be energized as well; if the microcontroller outputs is high level, the transistor will reach scanty and the relay will be cut off. Therefore, remote manager can control the switches of the electrical appliance.

3.2. The Design of Embedded Measurement and Control System Software

This plan is implemented through embedded measurement and control system. The monitoring of temperature, humidity, smoke and the control driving program of buzzer and short messages needed to be compiled and configured on the Linux cross development platform. At the same time, redundant drivers should be cut off and drivers that are useful to this platform should be retained. Finally, they will be downloaded to FLASH. However, the software of other measurement and control

server needs no change and can be used directly.

In addition, the middleware technology [10] can be used to make corresponding configuration, which makes remote measurement and control platform widely used in fields. In different situations, the data transmission at the higher layer and application programs need no change. The only thing need to be done is to change sensor and corresponding driver.

4. Conclusion

Based on the wireless sensor network, the embedded intelligent workshop remote measurement and control system platform is a normal web remote measurement and control structure. Its structure and key technology includes embedded technology, communication technology, web server technology and etc. Based on the wireless sensor network, this embedded intelligent workshop remote measurement and control system can not only applied in workshop monitoring, but also in other environmental monitoring, industrial control, intelligent city, intelligent home furnishing and other fields. Therefore, this will provide significant practical value to bring network advantage into full play and to the realization of artificial intelligence to promote social progress.

Brief Introduction to the Author

YueXiangyu (1992-), who is a male, Han nationality, was born in Weifang, Shandong, with BA, Nanjing University, mainly engaged in electrical information and automation, aesthetics and other aspects of learning and research, specializing in modern industrial embedded control systems, networked control systems, intelligent control. He presided over one national college student science and technology innovation project, taking part in the research on one "Eleventh Five-Year Plan" education and science key project of the Education Ministry, and one soft science research project of Shandong Province. He has 12 science and technology papers published in Chinese and oversea academic journals. He has won the 1st scholarship of China, the 1st scholarship of people, the 1st and the 2nd prizes of China Education Robotics Competition, the 1st prize of China Mathematical Modeling Contest, the top award of scientific research achievement of Nanjing University, two China science and technology patents and the honorary title, “three-good-student” of Jiangsu Province. In addition, as a representative of Nanjing University, he went to the National University of Singapore to participate in an academic exchange program. Address: School of Management and Engineering, Xianlin Campus of Nanjing University, 163, Xianlin Avenue, Qixia District, Nanjing, Jiangsu Province, PR China; Zip: 210008.

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