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Design of WSN-Based Remote Monitoring System for Environmental Parameters in Substation

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Abstract

According to the hidden danger of environmental security in unattended substation, the paper designs an environmental parameters remote monitoring system based on wireless sensor network (WSN), and achieves the part of data collection. In addition, the system can monitor the conditions of power distribution equipment and switches. The system improves the environment of substation and ensures the substation operation normally.

Keywords: Substation; wireless sensor network; environmental parameters; remote monitor

1. Introduction

The environmental parameters, such as temperature, humidity, water seepage of ground, etc. are the key factors of substations in electric networks. The manual inspection is still used in many substations in China. Such traditional method exposes evident disadvantages:

1) Time-consuming since the wide distribution of substations;
2) No timeliness of failure discovery;
3) Carelessness of inspectors;

Obviously, it is significant to establish a remote environmental parameters monitoring system in the substations. The substation environmental parameters of temperature, humidity, water seepage of ground and smoke are main monitoring objects of the system.

The WSN-based remote environmental parameters monitoring system proposed in this paper advantages over the traditional inspection method as follows: 1) it integrates three functions for data collection, data processing, and data transmission into the node of wireless sensor network (WSN) [1]-[3], which make the monitoring system used easily; 2) since the node of WSN uses wireless communication mode, it is more suitable for remote and harsh environmental areas; 3) it can monitor the spot in real time; any problems will be found and processed in time; 4) the system is high efficient, and it can save manpower and resource.

2. Overall Design of System

Fig. 1 shows the architecture of the presented monitoring system, which includes three parts: data collection module, data transmission module, and monitoring center. It collects information such as temperature, humidity, special switch signal, water seepage, equipment condition, and so on by the sensors. By combining with the real environment of the substation and meeting the conditions of

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converge, nodes are deployed reasonably in accordance with the principle of cost optimization. ZigBee protocol is used to transmit the data in the substations to the switch. Then the switch collects data and uploads them to monitoring center via the Internet. The monitoring system based on the B/S mode, and it can monitor the substation in real time.

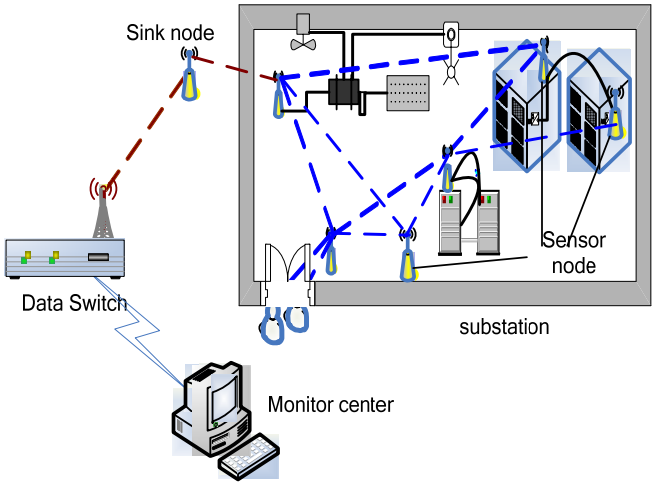

Fig. 1. The architecture of monitoring system.

Next, the paper focuses on the data collection module and data transmission module.

2.1. Hardware design of node in system

The node used in the system includes five parts: sensor module, power module, MCU (32-bit microcontroller Atmega1281), communication module (CC2430), and alarm module (see Fig.2).

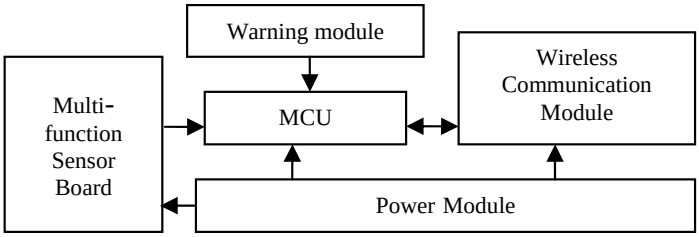

Fig. 2. The structure of wireless sensor node.

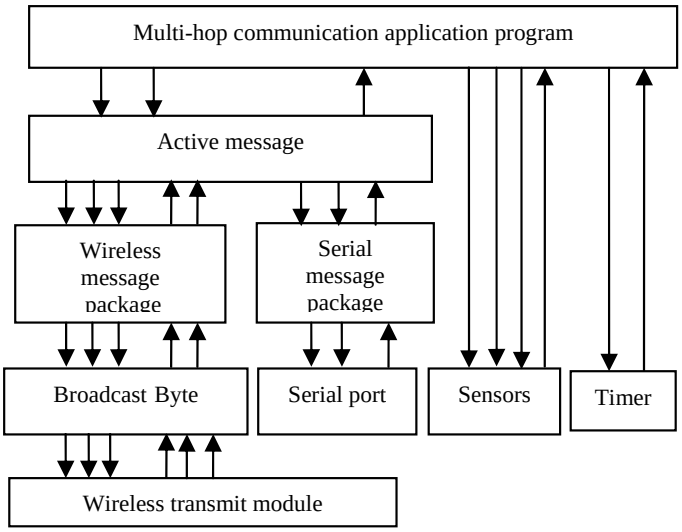

Fig. 3. The structure of the application program.

The sensor board contains the sensors of temperature, humidity, smoking, water seepage, etc. It meets the needs of different tasks. For example, if the temperature or smoke of the spot exceeds the threshold, the node can alarm at once.

2.2. Software design of node in system

TinyOS is an operating system for wireless sensor network. It uses event-oriented way of implementation and the features of NESC language to achieve the program's components, modular and multi-hop. The structure of application program is shown in Fig. 3. The node in the system transplant TinyOS to Atmega1281 which is the control core of the hardware platform.

3. Data Collection Module

As example, we consider the monitoring of substation temperature. The transformers and switchgear release a lot of heat during operating. If the temperature of substation is too high, the power equipment can't work normally. We can use the sensor deployed in the substation to collect temperature in real time, and control the air-conditioning, exhaust fan automatically according to the temperature. In addition, the system can avoid air-conditioning and exhaust fan working year-round.

3.1. Structure of temperature collection module

The sensor DS18b20 is applied to collect the data, which will be transferred to sink node through communication model CC2430. Sink nodes fuse the detected data, and transfer the data to the monitoring center by the Ethernet. The center will monitor the collected data in time by analyzing and predicting. Once a device fault is found, the system will send detailed information of equipment, which is required by staff via GPRS to improve maintenance efficiency and reduce losses. The temperature collection module is shown in Fig. 4. The temperature sensor node placed in spot is shown in Fig. 5.

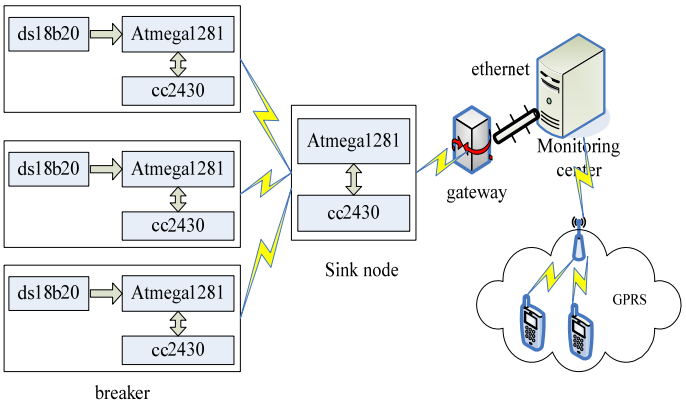

Fig. 4. Structure of temperature collection module.

Fig. 5. Temperature sensor node placed in spot.

3.2. Program flow chart of temperature collection

The main program initializes the DS18b20, Clock and LED, and then it set the Clock frequency. The program will collect information per second and write the data with time to the Memory.

The node can adjust the clock frequency and interrupt the task according to the control command from monitoring center. The program flow chart is shown in Fig. 6.

3.3. Program for data collection:

```
//Sensor initiation
command result_t sensor.init() {
atomic {
    TOSH_MAKE_wendu_CTL_OUTPUT();
    TOSH_SET_wendu_CTL_PIN();
```

```
      TOSH_MAKE_PW1_OUTPUT();
      TOSH_SET_PW1_PIN();/* power to sensor*/
      }
 }
command uint16_t sensor.temp_read_temp()
{
uint16_t i;
uint8_t buf[1];
atomic {
call sensor. temp _reset();
call sensor. temp _write_byte(0xCC);  /*ignore the address*/
call sensor. temp _write_byte(0xBE);   /*read temperature*/
for (i = 0; i < 2; i++) {
buf[i] = call sensor. temp_read_byte();
}
i = buf[1];
i <<= 8;
i |= buf[0];
    }
  return i;
  }
}
```

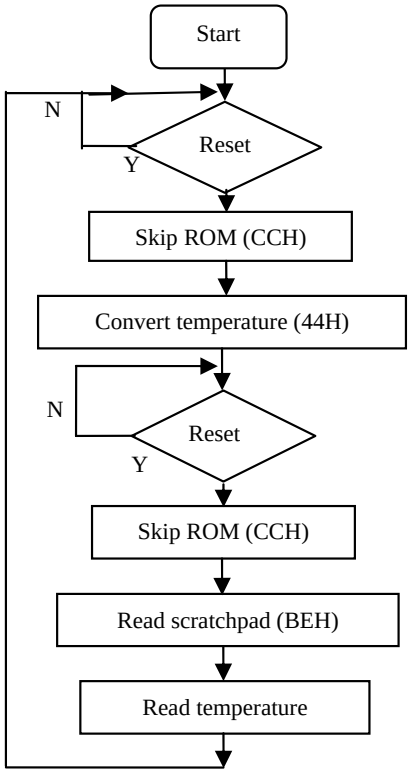

Fig. 6. The program flow chart.

4. Main Function of the System

4.1. Monitoring the temperature and humidity

In the substation, the humidity is too high to cause short-circuit of equipment easily. We can use sensor to detect environmental humidity. If the value exceeds the preset value, the system will start

dehumidifiers and heating equipment to increase the indoor temperature. If the temperature exceeds threshold, the system will start exhaust fan to decrease the humidity [4].

Sensor SHT11 is used to detect the humidity and temperature which is made in Switzerland Sensirion Company. It has features of strong anti-interference ability, low power and high accuracy. The device is shown in Fig. 7.

Fig. 7. The temperature and humidity sensor node placed in spot.

4.2. Monitoring the water seepage of ground

One of the necessary conditions to ensure the equipment to work normally is waterproof and rainproof. Especially in rainy season, the problem of water seepage often happens in substation. The water seepage of ground can lead to the risk of leakage and. Short-circuit of electrical equipment, even the occurrence of major accidents.

So it is necessary to establish a system of real-time monitoring the water seepage of substation. Once the monitoring center finds something abnormal, it can alarm in time.

4.3. Monitoring the temperature and smoke

When the data (temperature or smoke of the spot) exceeds the threshold, the node can alarm at once.

5. Extended Functions of the System

The system can monitor the environmental parameters; it can monitor the condition of power equipment in addition.

The system detects the equipment condition by kinds of sensors, and evaluates the condition of the equipments according to the data. It can judge potential fault (for example, if there is insulation phenomenon or not by detecting the oil chromatography and temperature), and remind the worker to maintain the device in time so as to reduce the risk of accident [5].

The temperature of electrical equipment is an important parameter to indicate whether the device operates normally or not. For example, the device switch contact is easy to oxidize owing to the ambient temperature, pollution, long-running, overload operation and arc shock. It will become hot as the temperature rises continuously, which is the hidden danger of the equipment. References [6] proposed the temperature sensor should be placed in guide plate of circuit breaker to collect data.

There is corresponding relationship between the phase current and temperature distribution. Usually the temperature difference of three-phase current is at 5℃-10 ℃. If the anomaly heat occurs by the influence of the certain phase current, the heat distribution will shift.

The temperature rise caused by phase A will be accompanied by the temperature change of phase C, so that the temperature of top guide plate is higher than that of the bottom. If the abnormal device isn't detected timely, it may cause the fire or explosion, resulting in property damage. It is more important especially for the unattended substation.

6. Conclusions

The paper designs a WSN-based environmental parameters remote monitoring system, which is based on 32-bit microcontroller Atmega1281. The design of sensor interface is modularized, so the system can be used to monitor a variety of environmental parameters. In addition, the features of the system are easy to expand.

Experiments show that the system is able to transmit data to the monitoring center reliably and stably when the substation is unattended. It avoids the problems of uninspected substation and ensures the substation works normally.

Acknowledgements

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