An RFID and Sensor Web-Enabled Smart Electric Power Equipment Inspection System

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Abstract—**People's daily lives depend on the power supply almost uninterruptedly in contemporary society, and the safe operation of power system is an important basis to ensure the safety and stability of industrial production and people's lives. Thus, inspection is necessary to ensure the safe operation of power facilities. Nowadays, there are three main kinds of inspection methods: traditional manual inspection, two-dimensional code inspection and inspection robot. However, each of the existing inspection method has its own disadvantages such as low efficiency, contact inspections and so on. Therefore, it makes sense to design a system to improve the efficiency and intelligence level, what is this paper does. The system in this paper has two main advantages RFID and multi-sensors, and the first realized a contactless and uniquely identified inspection, the second achieve all-day and real-time environmental monitoring. Above all, the system can realize a contactless, more comprehensive and effective inspection.**

Keywords- smart inspection; Radio Frequncey Identification (RFID); Sensor Web; WebGIS; smart city

I. INTRODUCTION

People's daily lives depend on the power supply almost uninterruptedly in contemporary society, and the transmission line is of great importance as the main artery to the power system [1]. Therefore, strengthening operation management of the transmission lines is critical. Line-inspection is an important way to ensure the safety of system for enterprises, and the following three inspection methods are the main mainstream approaches to perform this process, each of which has its own drawbacks.

1) Traditional manual inspection, which is the most widely used inspection method in the past decades. Traditional inspection methods mostly use paper record or special mark to mark the defects of power equipment, which is error-prone and difficult to conserve. What's worse, the inspection results cannot be reported in real time, and it's easily influenced by personal skills and difficult to be supervised.

2) Two-dimensional code inspection, which is more intelligent than traditional inspection [2]. However, the tags are easy to blur and be damaged. Besides, it needs close-range scanning, so it cannot meet the requirements of inspection of targets at high heights or somewhere hard to visit for inspectors.

3) Inspection robot, which is suitable for high voltage cable tunnel and so on [3]. However, the cost is too high for daily inspection, and its maintenance is difficult. What's worse, the robot is easily to be restricted by the geographical environment, so this method is not suitable for daily use.

Based on the above situation, a new power patrol inspection system is in urgent need, which can realize contactless and remote inspection, easy maintenance, low cost and can report inspection data in real time.

Radio Frequency Identification (RFID), one of the core technologies of the Internet of Things which is considered as the future evolution of the Internet [4, 5], can be used to uniquely identify objects in the physical world [6]. RFID tags can store a certain amount of data, which can be read and written. What's more, it has small size and can be made into various forms, which makes it easy to be put into various kinds of facilities. Due to the excellent features above, RFID has been widely used in smart logistics, smart museum, and smart tourism and so on. Power equipment are tagged in the system in this paper.

Sensor web is a type of sensor network that is especially well suited for environmental monitoring [7, 8, 9]. Through sensor web, sensor data can be discovered and transmitted using standard protocols and application programming interfaces. Sensor webs have been used in severe environment and have made a good performance in kinds of research. The technology can not only raise awareness of the environment context, but also control the environment by actuating devices.

From the studies mentioned above, it is apparent that RFID and Sensor Web technologies have shown great suitability and advantages for efficient object identification[10,11], ubiquitous sensing, and data transformation, which can meet the urgent needs of the inspection of electronic equipment. Based on this fact, this paper designs an electronic equipment inspection system using RFID and Sensor Web. The system can offer efficient and intelligent management for electronic equipment.

The following of the paper is organized as follows. Section 2 presents the design of the proposed system. Section 3 introduces a case study in Maoming, Guangzhou province. Section 4 concludes the paper.

Supported by the Grand Special of High resolution On Earth Observation: Application demonstration system of high resolution remote sensing and transportation (Grant NO: 07-Y30B10-9001-14/16), Project of Creative Research Groups of Natural Science Foundation of Hubei Province of China (No. 2016CFA003), the Union Foundation of Ministry of Education of the People's Republic of China (No. 6141A02231601), the National Nature Science Foundation of China (NSFC) Program (No. 41301441), the National Basic Research Program of China (973 Program) (No. 2011CB707101).

II. SYSTEM DESIGN

A. RFID and Multi-Sensor based Architecture

Considering the requirements for managing and inspecting electric equipment, and the excellent features of RFID and sensor web, this system is designed with three parts. The first part is the electronic equipment equipped with RFID tags which is bound by one temperature sensor and one humidity sensor that can collect environmental parameters and then send these collected data to the RFID reader. The second part is the PDA, which can be mobile phone or iPad or any other Android device. The smart electronic power equipment inspection system is installed on the PDA, which can get and process the environment data from RFID reader and send it to server-side information management system by wired transmission, or wireless transmission such as 3G, 4G and so on. The last part is the server-side information management system which is responsible for receiving and processing data transmitted from PDA. The whole architecture is shown in Figure 1.

Figure 1. Architecture of the proposed system

B. Fucntions of the Proposed System

The system aims to improve the efficiency of electronic power equipment inspection and management with RFID and multi-sensors, so the mobile terminal primarily consists of four kinds of functions: device information, petrol task, real time GIS and some other functions. Accordingly, the server side consists of four kinds of functions as well, including basic information management, petrol information management, statistics and query of patrol information, and system management respectively. Function structure is depicted in Figure 2.

Three main functional processes are described in the following subsections.

1) Management of Basic Information

Basic information consists of four parts: community information, power device information, inspector and department information, and sensors information.

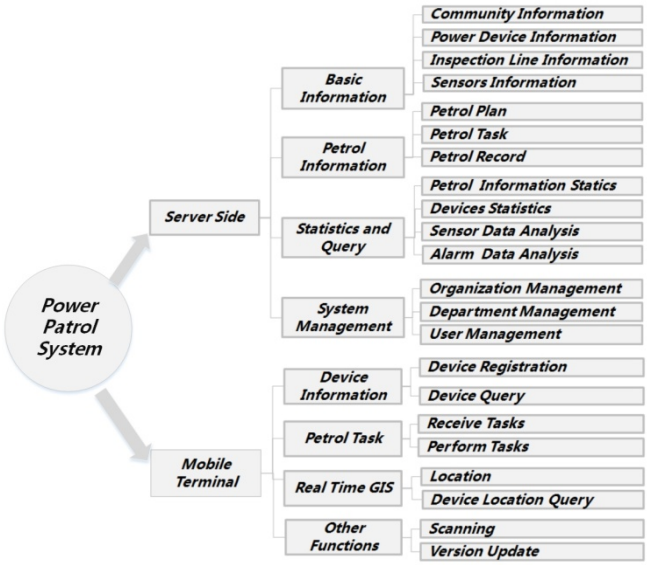

Figure 2. Functions of the proposed system

Community information is the basic information that is managed by the active user, and is added by the administrator user at server side. Power device information is added by the inspector using mobile terminal, and consists of RFID tag ID which is read by RFID reader, the device's name, the device's specification and type, the device's location and some other user-defined attribute information. All this information is filled out by active user of mobile terminal, and then transmitted to the server side by 3G, 4G, WiFi or other kinds of transmission means. Inspector and department information means the organization of the inspector, that is, a certain inspector belongs to which department, and the department belongs to which organization. All the operations of organization information can be only performed at server side. Sensor information includes information depicting which device is tagged with the sensor, it's upper and lower threshold that can be set by the active user in the mobile terminal. The process is depicted in Figure 3.

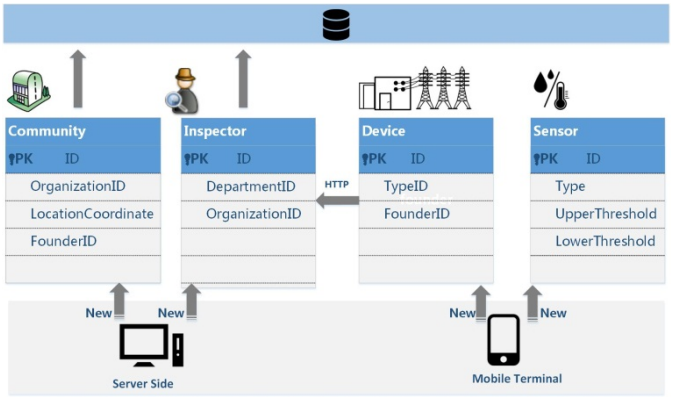

Figure 3. Process of the management of basic information

2) Management of Inspection

An inspection task is divided into three stages, the administrator of the server-side management system creates an inspection plan first, resulting several tasks according to the

plan time. Then the task is pushed to corresponding mobile terminal whose owner is the appointed inspector. The last stage is performing inspection tasks by the inspector. The process is depicted in Figure 4.

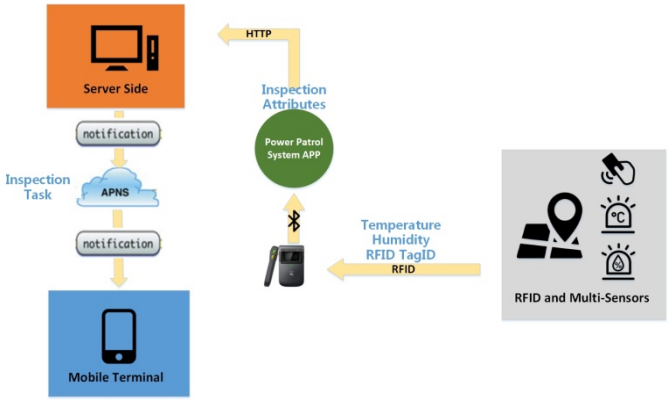

Figure 4. Process of the management of inspection

3) *Statistics and Query*

This part analyzes the contents of three aspects: inspection status and missed rate of inspection, defective equipment condition, and sensor data.

Inspection status and missed rate of detection is calculated by the data transmitted by the inspector, including the inspected device and inspection time, comparing with the total quantity in the inspected line, the administrators will get the headline data of inspection.

Defective equipment condition means how many devices in total are defective, as well as their distribution on inspection line. Data comes from the inspection data sent by mobile terminal.

Sensor data is the data sent by the sensor of temperature and humidity, the analysis of which can show its environmental situation, and if the numerical value is more or less than threshold value, it will send a warning. The process is depicted in Figure 5.

Figure 5. Three kinds of statistics and query

III. CASE STUDY

In order to test the proposed system, we applied it in a pilot area in cooperation with NARI Group and State Grid, and the pilot area is a community in Maoming, Guangzhou Province, China.

As is introduced in second section, all device are registered by mobile terminal, as is shown in Figure 6. When petrol task is pushed by server, the mobile terminal will get the task notification and remind the inspector of performing that, as is shown in Figure 7, and the task has three types of status, including unexecuted, under execution, and executed.

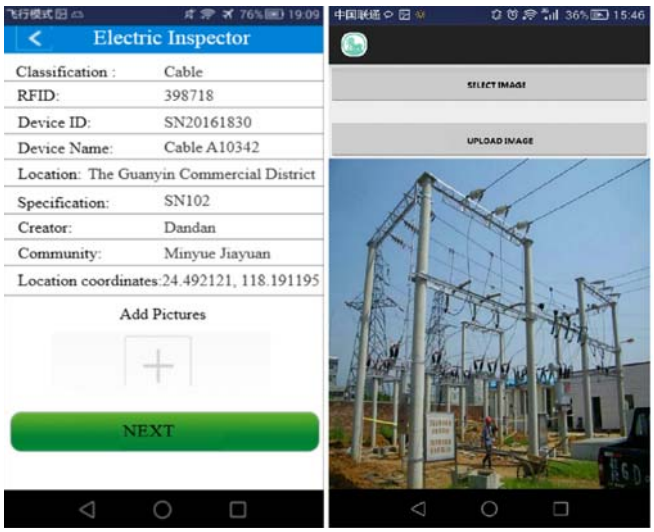

Figure 6. Registration page of electric equipment

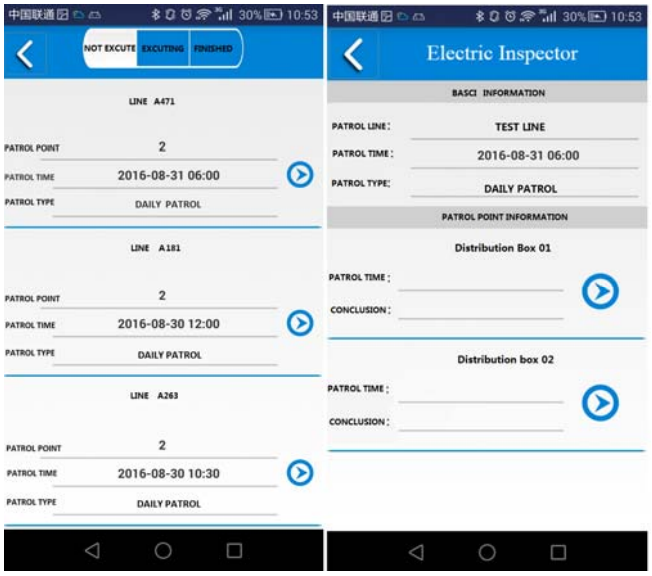

Figure 7. Inspection task page of electric device

The server-side management system is based on Browser/Server (B/S) architecture, and possesses functions of data acquisition, warning control, inspection feedback, inspection plan making, and maintenance history query.

As is introduced in second section, the background management system can provide basic information of community and devices on map to the system administrator, besides, the upper and lower threshold of sensor is made here by the users as well.

On the inspection aspect, all inspection plans are created by the users, for example, yearly plan, monthly plan, weekly

plan and some other unscheduled planning. All plans will generate corresponding tasks automatically, which is judged and executed by the program, and then will be sent to the mobile terminal.

Figure 8 is the real-time map of community and device, where the basic information and GIS information is shown. Figure 9 shows the data collected by multi-sensors, including temperature and humidity sensor values.

Figure 8. Real-time GIS based efficient management and dynamic visualization of electric equipment

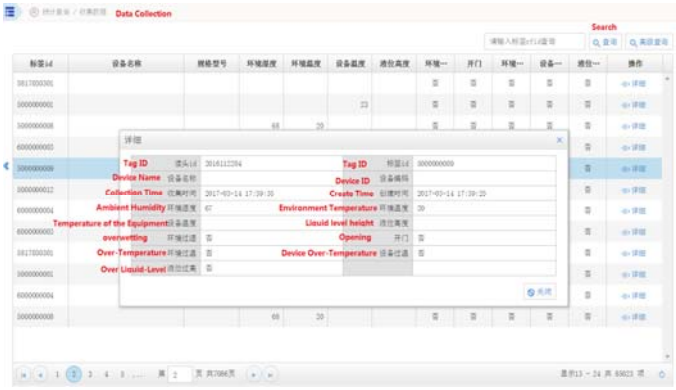

Figure 9. Multi-sensor monitoring page

IV. CONCLUSIONS

Power equipment is an important part of infrastructure, and the safe operation of power system is an important basis to ensure the safety and stability of industrial production and people's lives. Thus, power system inspection is necessary. The system in this paper is aimed to improve the efficiency and intelligence level of electronic power equipment inspection. The main advantages are as following:

(1) RFID is used in all devices. RFID tag has the advantages of convenient reading, fast identification speed, large data capacity, long service life and real-time communication. By using RFID, the contactless and real –time inspection is realized.

(2) Multi-sensors are used in all devices. All devices are tagged with temperature and humidity sensors, so the environmental conditions can be monitored continuously at all times, and real-time warning are realized.

Although the proposed system has been tested successfully and has shown its feasibility in efficient management and effective inspection of electronic power equipment, there are still some limitations. For example, the ambient sensors used in our system collect only the ambient air temperature and humidity around device, which is not enough for full ambient sensing and monitoring, and this is what I have to solve in our future work to make the management and monitoring more comprehensive and effective.

ACKNOWLEDGMENT

The authors would like to express appreciation to colleagues of GuiTian Tech., and colleagues in our laboratory for their valuable comments and other help.

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