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WSN-Based Intelligent Inspection Monitoring and Positioning System in Substation

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Abstract

To ensure the staff's security and supervise their work in order, an intelligent inspection monitoring and positioning system in substation is analyzed. Microwave sensor is used to monitor the high-risk work area in substation. When the microwave starts to work, the warning equipment will alarm anyone closed to the monitoring work area .The terminal will get the staff's specific location according to regional positioning algorithm. The system can draw the inspection track and display it in real time. It improves the safety of substation.

Keywords: Substation, wireless sensor network, inspection monitoring, regional positioning algorithm

1. Introduction

Substation is one of the most important parts of power system. 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) Carelessness of inspectors;
3) Dangerous for inspector since substation is high-risk work area;
4) No timeliness of failure discovery;

Obviously, it is significant to establish an aid inspection monitoring and positioning system in substations, which is useful to the inspectors and manager.

The WSN-based intelligent inspection monitoring and positioning system proposed in this paper advantages over the traditional monitoring method as follows: 1) It integrates three functions for data collection, data processing, and data transmission into the node of wireless sensor network (WSN) 0-0, which make the monitoring system used easily; 2) Since the node of WSN uses wireless communication mode, it is more suitable for substation which is in 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[4].

2. Overall Design of the System

The functions of the system are: 1) Exactly positioning of staff that entered monitoring area; 2) Real-time monitoring the high-risk work area and non-work area and timely warning to abnormal behavior; 3) It can record and replay the inspected track, and avoid careless inspecting occurs.

Fig. 1 shows the architecture of the presented system, which mainly includes three parts: monitoring centre, WSN communication network and terminal (see Fig. 2). The terminal includes three parts: sensor,

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sound and light alarm module and WSN node. Monitoring centre can display data real-timely. In case of emergency, monitoring centre can control terminal.

By combining with the real environment of the substation, nodes are deployed reasonably in accordance with the principle of cost optimization. Then the sink node collects data and uploads them to monitoring center via the Internet.

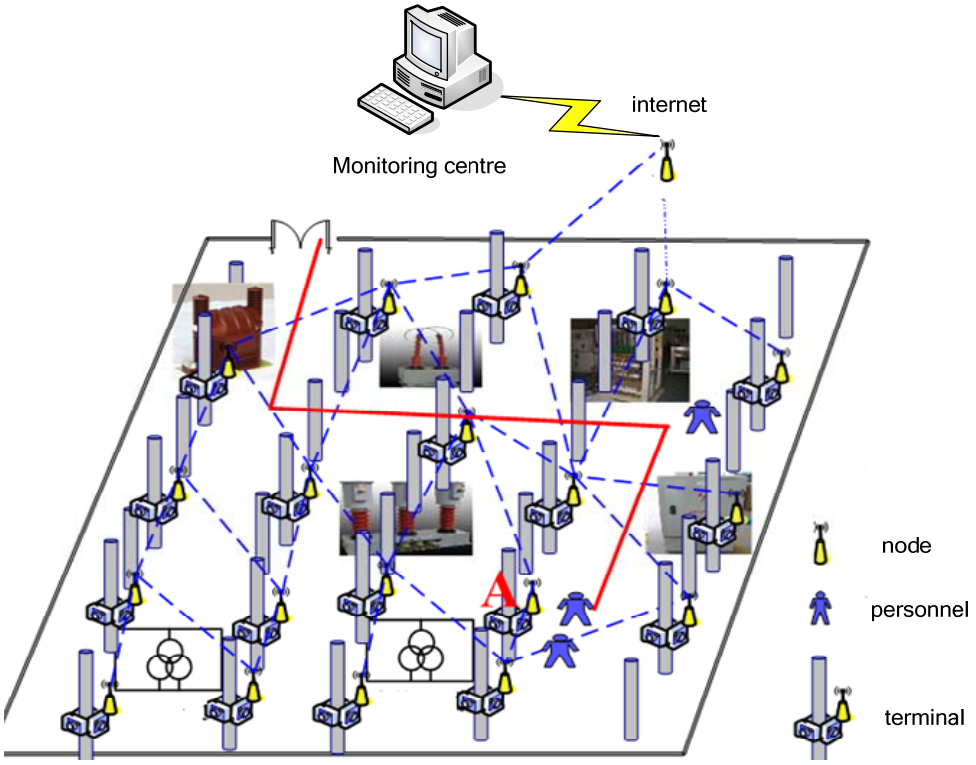

Fig. 1. Architecture of inspection monitoring and positioning system (Solid line is the track of inspector.)

2.1. Structure Station troops on garrison duty

The terminal (see Fig.2) is installed in high-risk work area of substation. When it receives “start” command from monitoring centre, the microwave sensor will start to work. In this case, if anyone enters the monitoring area, the terminal will start light and sound alarm. At the same time, abnormal event will be uploaded to the monitoring centre and real-time displayed in monitoring system.

(a) (b)

Fig.2. (a) The installation site of Zhoukou Fumin substation (b)The photo of On-site installed terminal

2.2. Regional positioning algorithm

The flowchart of regional positioning algorithm is shown in Fig.3:

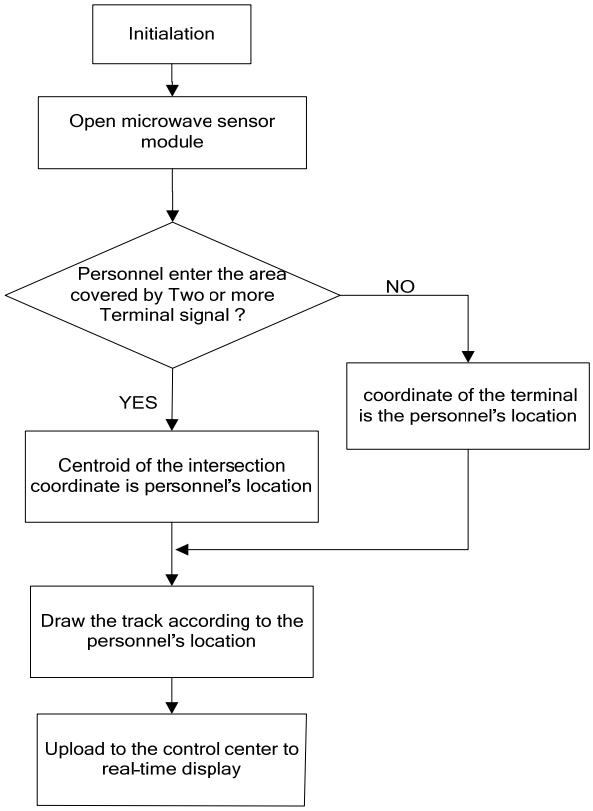

Fig. 3. Flowchart of regional positioning algorithm

When someone enters the monitoring area, the regional positioning algorithm can get staff's specific location coordinates, which is useful to deal with the abnormal event. The principle of the algorithm is shown as follow:

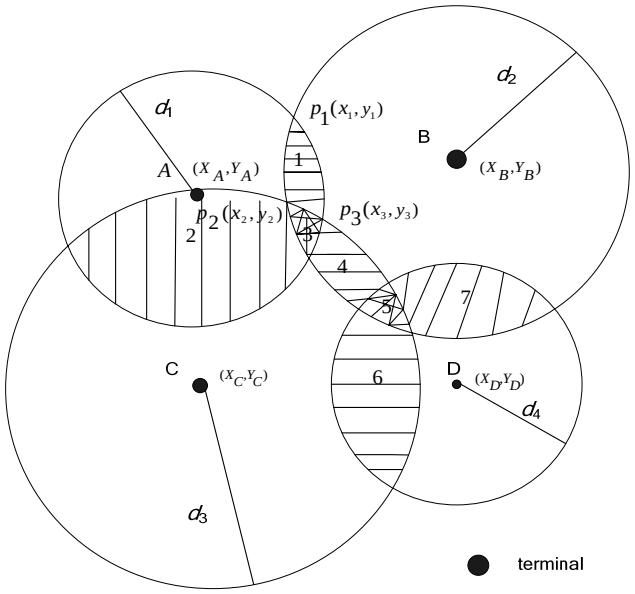

Fig. 4. Diagram of positioning system

The terminal's coverage area is the circle area, whose radius is the sensing distance of the terminal (see Fig.4). Assume A, B, C, D are four terminals, coverage radius are d_1, d_2, d_3, d_4. The shaded part is overlapping covered by two or more terminals, such as region 1, 2, 3, 4, 5, 6, and 7. The remaining area is covered by one terminal.

1) When the monitoring area is covered by two or more terminals, positioning algorithm is explained as follow:

At first, it calculates the centroid coordinate of some intersections, which is the coordinate of staff. Region 1 is an example to explain the algorithm:

At first Calculating p_1Coordinates(x_1,y_1)：

$$\begin{cases}(x_A - x_1)^2 + (y_A - y_1)^2 = d_1^{\,2} \\ (x_B - x_1)^2 + (y_B - y_1)^2 = d_2^{\,2}\end{cases} \Rightarrow (x_1, y_1) \tag{1}$$

Calculating p_2 Coordinates(x_2,y_2):

$$\begin{cases}(x_c - x_2)^2 + (y_c - y_2)^2 = d_3^{\,2} \\ (x_B - x_2)^2 + (y_B - y_2)^2 = d_2^{\,2}\end{cases} \Rightarrow (x_2, y_2) \tag{2}$$

Calculating p_3 Coordinates(x_3,y_3):

$$\begin{cases}(x_A - x_3)^2 + (y_A - y_3)^2 = d_1^{\,2} \\ (x_c - x_1)^2 + (y_c - y_1)^2 = d_3^{\,2}\end{cases} \Rightarrow (x_3, y_3) \tag{3}$$

Then calculating centroid of the three intersections, which is the coordinate of staff is(x, y)：

$$(x, y) = (\frac{x_1 + x_2 + x_3}{3}, \frac{y_1 + y_2 + y_3}{3}) \tag{4}$$

2) When the monitoring area is covered by one terminal, the coordinate of the terminal is the coordinate of staff.

The regional positioning algorithm proposed in this paper advantages over others is easy to implement, Since the Staff needn't carry any mobile label. It can draw the inspection track according to the staff's location, and display it in real time. Staff's inspection tracking is shown in Fig.5.

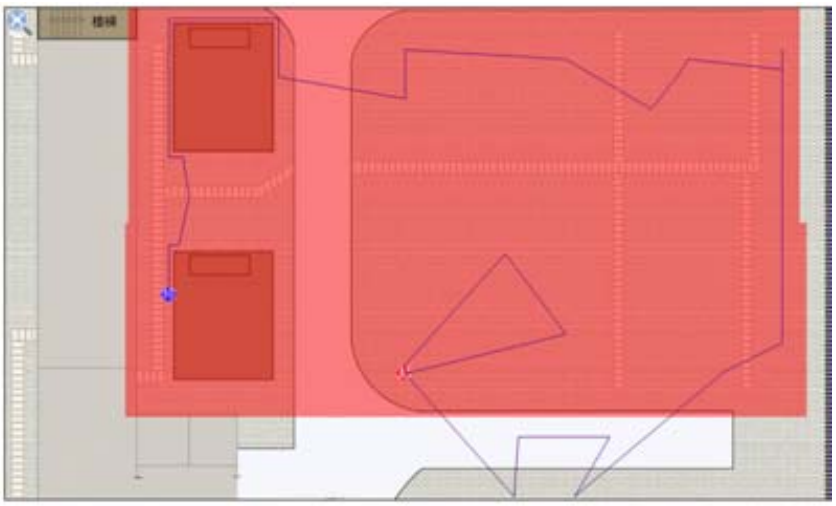

Fig.5. Diagram of staff's inspection tracking

2.3. The Monitoring and positioning system

The monitoring centre receives data from terminal, and real-time display them. The manager can monitor the scene and deal with emergency events on time. Case of emergency, it can send command to control terminal. The function module of the system is shown in Fig.6[5].

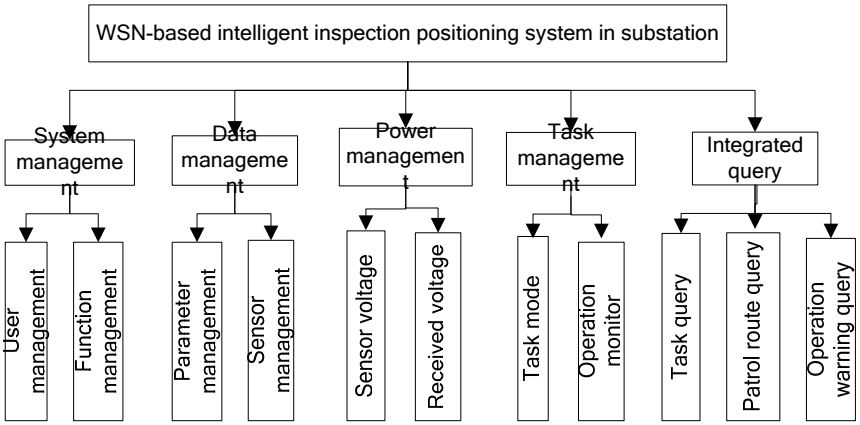

Fig.6. Function module of monitoring and Positioning system

Power management: It can monitor the node's voltage in real time. When the power is low, the system can alarm and remind the staff to replace the battery timely (see Fig.7).

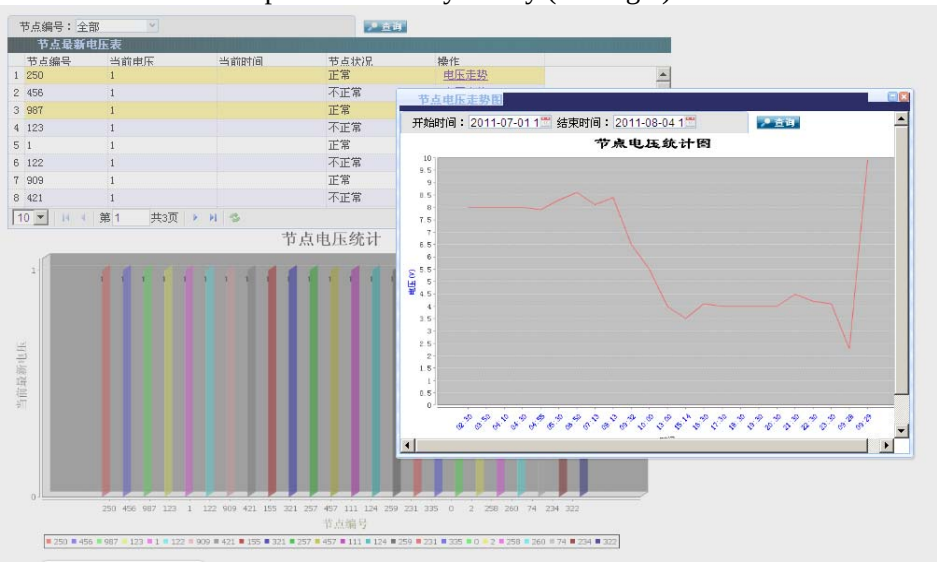

Fig.7. Diagram of monitoring node voltage

3. Conclusion

The paper designs and implements an inspection monitoring and positioning system, which can get the stuff's specific location and alarm anyone closed to the monitoring work area. It is useful to the manager of substation. The system can effectively manage and supervise types of operations security in substation. It can eliminate the illegal operations and improve the level of safety management of substation.

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