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Development of Landslide Information Acquisition-transmission System Based on Wireless Communication Technology

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Abstract. Wireless communication technology has been used widely, different technologies have different application range and applicability. In this study, several commonly used wireless communication technologies were comparatively analyzed on the transmission rate, use cost and power consumption, and so on. It is concluded that the characteristics of ZigBee technology accord with the research needs, and it has many advantages in landslide disaster remote monitoring applications. Wireless sensor network was established based on ZigBee technology, then planar landslide information acquisition transmission system was developed, and immediately applied in engineering fields. Application results show that the system runs stable, and its effect is really good, which provides powerful support for later promotion.

I. INTRODUCTION

At present, the common short-range wireless communication technology mainly includes, Wireless Local Area Network 802.11 (Wi - Fi)[1,2], Bluetooth[3,4], Infrared Data Association (IrDA)[5,6] , Home Radio Frequency (HomeRF)[7], Radio Frequency Identification Devices (RFID)[8], ZigBee[9,10], and so on. All of them have different characteristics, and can be applied in different fields. They compete with each other and can be mutually complementary.

Along with the rapid development of modern science and technology, the application range of wireless communication technology is more widely. According to the research status of landslide disaster monitoring methods, a new approach for landslide monitoring based on wireless communication technology is proposed, through selecting proper wireless communication technology, wireless sensor network was established, and then planar landslide disaster information acquisition-transmission system was successfully developed.

II. WIRELESS COMMUNICATION TECHNOLOGY SELECTION

Generally speaking, along with the increase of communication distance, the complexity of the equipments, power consumption and the system costs are rising. However, the landslide remote monitoring system needs small amount of data transmission, transmission rate is low, monitoring equipment in outside fields usually adopts batteries, so transmission equipments are required to be with lower cost and lower consumption. According to above requirements, this paper makes comparative analysis for existing wireless communication technology (Table 1).

A. Comparative Analysis. Through the above contrast, it can be found that, compared with all kinds of the existing wireless communication technology, ZigBee technology is of low power consumption and low cost, at the same time, because of its characteristics of low data transmission rate and small communication range, ZigBee technology is determined to be suitable for carrying business of smaller data flow.

TABLE 1. COMPARATIVE ANALYSIS FOR WIRELESS COMMUNICATION TECHNOLOGY

Technical Standard	Wireless Communication Technology					
	ZigBee	*Bluetooth*	*WLAN 802.11*	*IrDA*	*RFID*	*HomeRF*
Operating frequency	2.4GHz	2.4GHz	2.4GHz	820nm	5.8GHz	2.4GHz
Coverage area	50m~300m	10m	<30m	5m	1m~10m	50m
Transmission rate	250Kbps	1Mbps	<108Mbps	<16Mbps	212kbps	1.2Mbps
Link number	65000	7	255	2	2	127
Access time	30ms	10s	3s	3ms	3ms	1.28s
Maximum power	1mW~3mW	<100mW	100mW	10mW	0	50mW
Use cost	low	low	middle	low	low	middle

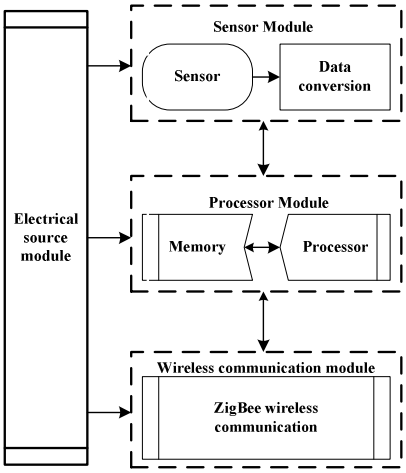

Figure 1. Sensor node structure diagram

B. Main Characteristics of ZigBee Technology. In recent years, ZigBee technology has been developing as a two-way wireless communication technology, which is mainly suitable in automatic control and remote control field, and can be embed into various equipments, this technology can also be considered as supports geological positioning function. The characteristics of ZigBee technology are basically as follows.

- Low power consumption

Transmission power is only 1mW, in the dormant low-power standby mode, twoNo.5 dry batteries can support a node to work for six months to two years, or even longer.

- Low cost

ZigBee module only cost several dollars, and through greatly protocol simplification (less than a tenth of the Bluetooth), requirements of communication controllers are decreased, according to the forecast analysis, with 8051 8-bit microcontrollers estimation, full-featured master node needs 32KB size code, subroutine node needs the code little to 4KB size, and ZigBee can exempt agreement charge.

- Low transmission rate

ZigBee works in low transmission rate of 20 to 250 kbit/s, which separately provides raw data throughput of 250 kbit/s (2.4 GHz), 40 kbit/s (915MHz) and 20 kbit/s (868 MHz), to satisfy the low speed transmission.

- Close range

Generally, transmission range is between 10 ~ 100m, and the transmission range will be further if through the communication relay between route and nodes.

- Short time delay

The response speed of ZigBee is much faster, generally, it only takes 15ms from sleep into working state, and 30ms for node into the network, so as to further save the electricity.

- High power capacity

ZigBee can adopt satellite, tree and mesh network structure, through a master node number to manage the sub-nodes, a master node can manage 254 nodes at maximum, meanwhile, the master node can be managed by the upper network node, which can form a large network with more than 65,000 nodes at most.

- High security

ZigBee provides a set of three-level safety modes, including no security settings, using access control list (ACL) to prevent illegal data obtaining, and adopting symmetric passwords with the advanced encryption standard (AES - 128) to determine its security attributes flexibly.

The characteristics of ZigBee technology determine its unique advantages that can accord with the requirements of landslide disaster monitoring data transmission, therefore, the establishment of landslide monitoring wireless sensor network is realized in this study.

III. ESTABLISHMENT OF WIRELESS SENSOR NETWORK

A. Wireless Sensor Network Description. Wireless sensor network is a self-organization wireless network composed of sensor nodes, node is the basis of the whole network, wireless sensor node is embedded and micro, which constitute the basic support platform of wireless sensor network. Nodes with different function need different hardware foundation.

B. Structure of Wireless Sensor Node . The internal structure of the wireless sensor node mainly consists of four parts, such as, wireless communication module, sensor module, microprocessor module and power supply and management module. With ZigBee short-range wireless communication technology, wireless communication module is responsible with other nodes for wireless communication, to send the data and exchange control information, Sensor module is responsible for monitoring area within the scope of information collection and data transformation. Microprocessor module is responsible for controlling of the sensor node, processing the data collected from itself and other nodes, including synchronization positioning, power management, task scheduling and communication protocol, Power supply and management module provide all the necessary power for normal work of sensor nodes. Sensor nodes functional modules as illustrated in Fig. 1.

C. Structure of Communication Node. However, the task of communication node just transmits data, no need to undertake data acquisition, accordingly, it is actually a sensor node with sensor module taken out, as illustrated in Fig. 2.

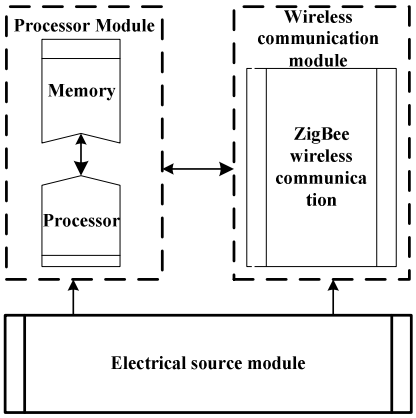

Figure 2. Central station structure diagram

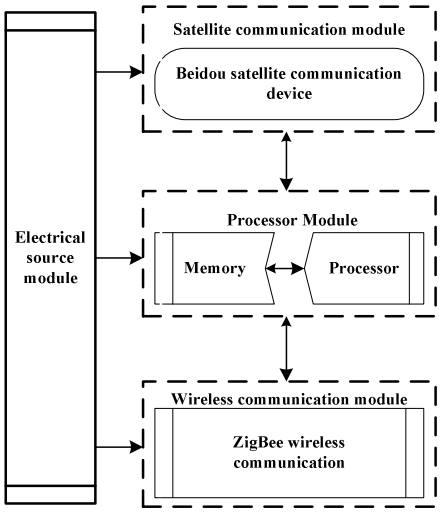

Figure 3. Central station structure diagram

D. Structure of Central Station. Similarly, central station does not need to acquire sensor data, but should be responsible for the work of data collection and transmission, therefore, in addition to the differences of internal microcontroller program and sensor node, satellite communication module still need to be added, so as to communicate with beidou users machine, as illustrated in Fig. 3.

E. Mesh Topology Structure. Wireless sensor network plan to take mesh topology structure as illustrated in Fig. 4, in this structure, all the node status are equal, each node will automatically search the most recent node for data transmitting, and will not communicate with central station directly. Although this structure is relatively complicated, it has strong redundancy. Even if a node of the structure appears problem, the data transmission of other nodes will not be affected. Once a node is damaged, related nodes will automatically adjust the route of network to transmit data through other nodes.

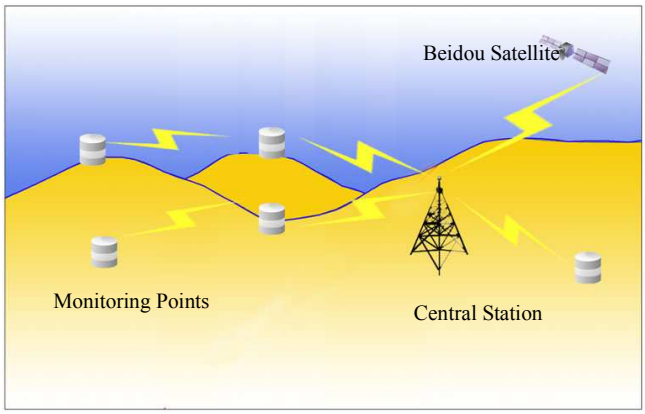

Figure 4. Mesh topology structure of wireless sensor network

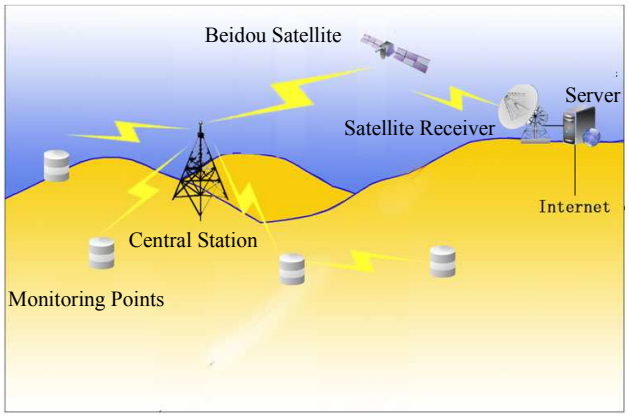

Figure 5. Overall network structure of Landslide Information Acquisition-transmission System

IV. REALIZATION OF PLANAR LANDSLIDE INFORMATION ACQUISITION TRANSMISSION SYSTEM

A. Planar Landslide Information Acquisition Transmission System. Planar landslide information acquisition transmission system is a kind of extremely resources limited distributed systems essentially based on wireless sensor network. In the network of wireless sensors, a large amount of wireless independent nodes, through mutual cooperation and labor division to complete the data acquisition, processing and transmission.

Based on the current development situation of wireless sensor network technology, and drawing lessons from domestic and foreign research experience, according to slope complex environment, this study analyzes the system structure, designs a kind of planar landslide monitoring information acquisition transmission system structure suitable for landslide monitoring, the general structure of the whole system as illustrated in Fig. 5.The structure is a hierarchical network structure, which is composed of three major components, the sensor nodes, gateway nodes (central station) and remote management center. The bottom of the structure is composed of several wireless sensor nodes installed in monitoring site, which can collect sliding force data. Through the processing by microprocessor built-in sensor nodes, the sensor nodes form network through ZigBee communication mode and send the data to center in the multi-hopped way cooperated with nodes in group. Then the data can be sent to indoor receiving-analysis center to be received, stored, processed, and released.

The advantages of planar landslide disaster information acquisition transmission system application for landslide monitoring are as follows.

1) Large scale, high density of network nodes, can reduce the precision requirements of single node sensor, the system has strong fault-tolerant performance. A large number of nodes can increase coverage of monitoring area in order to reduce blind spots.

2) There is no absolutely control center for the system, all the nodes status are equal, no need for intervention and any other preset network facilities, the network can be formed automatically and rapidly at any time anywhere.

3) The system network nodes have mobile ability, system can quickly adapt to and solve the mutual interference among radio channels, the influence resulted from terrain and weather comprehensive factors, the system also has dynamically reconfigurable performance.

V. CONCLUSIONS

(1) The introduction of ZigBee wireless communication technology, reduced the construction and operation cost of the planar landslide disaster information acquisition transmission system, at the same time, greatly reduced the system power consumption.

(2) Conditions in the landslide monitoring site are complex and changeable, monitoring points may need to be added, removed, or mobilized at any time for engineering requirements, the characteristics of wireless sensor network, especially flexible network mode of the system is cater to the needs of the consumers.

(3) Planar landslide disaster information acquisition transmission system has been applied on 158 monitoring points in 11areas, including large open pit mines, landslide areas, road side slopes, tunnel entrances, slope monitoring along the gas pipeline, stability monitoring of slope due to seismic, stability monitoring of active fault, and so on. According to the feedback, it is demonstrated that the system runs stably, and the application effect is very favorable.

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