Slope geological monitoring system based on wireless sensor transmission protocol research

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Abstract. With the continuous development of modernization in the central and western regions, the construction speed of the Panshan Highway has accelerated, and a large number of slopes have been formed. In order to ensure the safety of road vehicles in Laoshan District, it is necessary to monitor the safety of dangerous slopes, so it is essential to establish a complete slope geological monitoring system. Based on the development of wireless sensor network technology, the key technology of wireless sensor network technology based on slope monitoring system is studied, and a simple and effective wireless sensor network protocol is designed. The protocol architecture is divided into four layers, of which the link layer is mainly based on the IEEE802.15.4 protocol technology. The routing layer is mainly based on DSR technology, but it proposes a new method to solve routing loop problems, and designs a cooperative working mode of link protocol and routing protocol. Slope geology based on the agreement. The monitoring system is well monitored for the safety of dangerous slope geology.

1. Introduction

With the continuous development of modernization in China's central and western regions, the construction speed of panshan highway has been accelerated. The completed part of the highway is in or about to be in a dangerous environment due to the limitation of the rock and soil structure of the mountains on both sides. The threat of slope landslide to highway safety cannot be ignored. Slope landslide in an inappropriate and unforewarned time may bring a large number of casualties, and will bring bad social impact.

Landslide often brings loss of people's life and property. After the 1980s, more than 550 people were killed in the subsequent landslides in yanchi river, hubei province, jipizi landslide in the Yangtze river, and xitan landslide in the three gorges, resulting in direct loss of tens of millions of yuan of property and hundreds of millions of yuan of post-treatment fees [1]. Therefore, it is necessary to establish a timely landslide warning system to reduce the losses caused by landslides.
At present, some progress has been made in the research of landslide disaster warning. However, with the deepening of research, there are also many phenomena that are difficult to explain, and the reasonable explanation of these phenomena requires a lot of measured data to support, especially the measured data in the later stage of the landslide. However, the later stage of landslide is also a dangerous period of landslide at any time. In this period, the method of manual test is very unreasonable, so it is necessary to study the slope warning system without any participants.

2. Demand Analysis of Slope Monitoring System
Slope monitoring system consists of the front end data in data acquisition system, transmission system, such as the back-end data processing system of three most, the integrated use of the sensor and detecting technology, communication technology, computer technology, geotechnical engineering, such as multi-disciplinary knowledge, monitoring, control and communication functions in an organic whole, through a series of related activities, implementation structure of slope rock body parts move, tilt, soil moisture, rainfall, pore water pressure and the change of environment the continuous automatic monitoring of data. This series of related activities includes: the perception and detection of data indicators; Realize the collection and transmission of data information; Conduct data analysis and processing, status monitoring and trend prediction; State warning and information release according to the danger level; Conduct status query and information feedback as required.

3. System Architecture Design of Slope Monitoring System
The front-end data acquisition system at the bottom left of the figure is mainly composed of monitoring nodes, which are responsible for collecting the internal displacement, humidity and rainfall of slope rocks and soil. The upper left is the data transmission system, which is composed of base station and monitoring node, and is responsible for uploading and collecting data. On the right is the back-end data processing system, responsible for the construction of landslide model and early warning.

4. Wireless Sensor Network Communication Protocol Design
4.1. Design of Communication Protocol Physical Layer
The communication protocol specifies that the role of the physical layer is to specify the physical channel, modulation mode, and channel communication rate, and UTC4432 module is selected as the communication hardware of the physical layer. The relevant parameters of the physical layer under the selected module are as follows.
UTC4432 provides that the working channel can be selected from 430MHz to 450MHz, and in order to reduce the same frequency interference step should be more than 1MHz. The specific communication parameters provided by UTC4432 are shown in table 1.
Table 1. Physical channel information

| Spectrum   | Modulation Method | Bit Rate (kbps) |
|------------|-------------------|-----------------|
| 433MHz     | FSK               | 40              |

In the process of network operation, the physical layer needs to activate and close the wireless transceiver, conduct channel selection, channel energy detection, link quality indication and idle channel evaluation.

Among them, channel energy detection, link quality indication and idle channel evaluation can all be realized through the field strength detection function provided by UTC4432.

The communication protocol selects the way to judge the channel energy to judge whether the channel is idle or not. The main factors to be considered are that too high channel energy will reduce the signal to noise ratio and increase the bit error rate of transmission signals. If frequent retransmission is caused, the network channel will further deteriorate and may affect the real-time performance of the entire network. Therefore, no matter it is caused by the outside world or the high channel energy caused by the network itself, it should not attempt to send information and add extra burden to the channel. Link quality indicators can provide link information for routing.

4.2. Design of Communication Protocol Data Link Layer

In IEEE802.15.4 protocol, it is stipulated that the data link layer mainly undertakes six tasks: sending MAC beacon, coordinating and synchronizing the network; Support network association and unassociation operation; Support communication security; Provide physical channel sharing mechanism; A time slot guarantee mechanism (GTS mechanism) supporting non-competition; Provide reliable links for peer to peer network nodes.

In the data link layer, IEEE802.15.4 provides two link establishment modes: beacon enable mode and beacon disenable mode. The performance of beacon enable mode is much lower than that of beacon enable mode.

In beacon enable mode, a beacon is used to synchronize the time period of a network. Each communication cycle is a super frame, which is composed of active period and dormant period. Among them, the active phase is for information interaction, and the dormant phase is to make the whole network sleep periodically in order to extend the network life. The beginning of the superframe is defined as the moment when the coordinate point sends out the beacon frame, and the beacon frame contains the duration of the superframe and the information of time allocation. The beacon frame is followed by the competitive permission period (CAP), during which each communication node in the network can send information in a competitive channel in a specified way. After the competitive period, after the period of non-competitive period (CFP), also known as GTS (Guaranteed Time Slots). GTS time slot requires nodes to be applied during the competition period. Once some nodes apply for GTS time slot, they can be directly used when GTS time slot arrives. In the beacon enable mode, the superframe structure is shown in figure 2.

Figure 2. Beacon frame
The whole superframe period is constituted by the beacon series (BO) and superframe series (SO), and ‘aBaseSuperframeDuration’ is a constant value, which represents the number of symbols occupied by the superframe when the superframe series is 0 and the value is 960 (15.36ms).

4.3. Design Concept of Link Protocol based on Slope Monitoring System
Considering the large delay of multi-hop transmission in IEEE 802.15.4 protocol, this paper proposes a link access technology Admac which is more suitable for multi-hop transmission and has a small link layer delay. The technology is a closer link management technology of distributed technology, compared with the centralized technology, distributed technology's biggest advantage is can rapid response changes in the environment, and the difficulty of distributed technology is the distributed technology results are often not optimal results, lack of all global information will inevitably lead to the result, but this can be achieved by delicate design and some optimization, the design of global information are important and difficult to distinguish the important and not important global information, and through the global design patterns to share important information, ignoring important global information, In order to obtain the index data of the established network can meet the specific needs.

Admac technology mainly serves for slope monitoring network, which is a kind of proprietary network. In this proprietary network, there are only two types of packets sent from the application layer: those sent from the base station (known as the PAN coordinator) and those uploaded by the monitoring nodes. The data packet sent by the base station is considered as the expected large data packet, while the data packet uploaded by the sensor node is usually only a few bytes, which can be considered as a small burst data packet, with the data packet size ranging from 9Byte to 19Byte. Therefore, considering the characteristics and Qos requirements of the two types of data packets, CAP time period and GTS time period are set by referring to IEEE802.15.4 protocol, in which CAP time period serves the services with high real-time performance, while GTS time period serves the services with low real-time performance.

Admac technology serves the routing protocol of multi-hop networking. In multi-hop networking, the main interference to the network performance is the periodic beacon frame, which will bring unwanted network load. Therefore, the Admac technology chooses to cancel the periodic beacon frame and change it to the synchronization time when entering the network. Later, the synchronization of network time is completed entirely by the network synchronization protocol, which is located in the GTS period instead of the CAP period.

5. Wireless Sensor Transmission Protocol Test for Slope Monitoring System
The experimental site of the project is located in the G50 shizhong expressway section of the shanghai-chongqing expressway. The left side slope of the project is K1510+300. The starting and ending pile Numbers are K1510+100~ K1510+800. The strata are monoclinal, the geological structure is simple, and the strata are the filling soil of the quaternary holocene, the massive stone soil and the shale of the lower part of the middle lower Jurassic ziling formation. The groundwater is poor and the hydrogeological conditions are simple. At present, the reinforcement measures of this slope include the reinforcement of the whole slope with prestressed anchor cables, the closure of the slope with shotcrete, and the reinforcement of the second grade slope with anti-slide piles. The actual slope map is shown in the figure 3:
Based on the analysis of the natural environment and geological conditions of the slope, the stability of the slope is preliminarily judged. The top of the slope is arranged from top to bottom, 10 points are arranged for each sliding belt, two inclinometer and a cable displacement meter are installed at each point, and the upper and lower nodes are connected by cable sensors. Base stations are arranged according to the topography and relative positions, and the general layout of the project is shown in the figure 4.

The monitoring point of this section requires the monitoring node to return monitoring data according to a specific time length, which shall be uploaded once a day. Slope data collected by node monitoring equipment are shown in figure 5.

In the figure, the measurement date on the far right shows the time when the monitoring point uploads data to the base station. Except for measuring points 4 and 7, the time when other measuring points upload data to the base station is 10:32:06. From the time shown in the figure, the function of this slope monitoring system is normal with good real-time performance, which is almost within 1S.
The measured data of slope shallow slope Angle within one month from the measuring point 8 of the slope monitoring system are shown in figure 6.

![Monitoring data of inclinometer](image)

**Figure 6. Monitoring data of inclinometer**

As can be seen from the figure, the data of the inclinometer in one month is continuous and there is no packet loss. The system has been running since October 2018, and no packet loss or other phenomena that seriously affect the stability of the system have been found. A small number of bugs appeared in November 2018 and January 2019 respectively. After wireless program upgrade and BUG repair, the bugs did not appear again.

6. Summary

Based on the development of wireless sensor network technology, the key technology of wireless sensor network technology based on slope monitoring system is studied, and a simple and efficient wireless sensor network protocol is designed. The protocol architecture is divided into four layers, in which the link layer is mainly based on IEEE802.15.4 protocol technology. The routing layer is mainly based on DSR technology, but it puts forward a new way to solve the problem of routing loop, and designs the cooperative working mode of link protocol and routing protocol. The test performance meets the design requirements, stable and reliable, with a certain practical value.

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