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# Research on the Architecture of Slope Monitoring Platform Based on Edge Computing

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***Abstract:*** *Slope landslide caused by various geological and natural environment factors is a major geological disaster. Automatic monitoring of slope is one of the important measures to prevent landslide. At present, the country has established the norms for the prevention and control of geological disasters, and the natural resources, transportation and other departments for slope monitoring are studying to establish the professional norms for slope prevention and control on the basis of the national norms for the prevention and control of geological disasters, but no consistent norms have been formed. At the same time, there is no unified monitoring platform for all departments, industries and even monitoring units, and the monitoring information is isolated from different monitoring ranges, which is not conducive to the prevention and control of geological disasters. It is of great social and economic significance to establish a global multi-factor slope automatic monitoring platform for the prevention and control of landslide geological disasters. Therefore, based on the edge computing technology, this paper studies the multi-factor automatic monitoring of slope, as follows: 1. Analyze the demand of multi-factor automatic monitoring of slope. 2. The architecture of multi-factor automatic monitoring platform for slope based on edge computing is constructed.*

***Keywords:*** *edge computing; Slope monitoring; Automatic monitoring; Monitoring platform*

## 1. Introduction

Before the appearance of edge computing, traditional cloud computing [1] transmitted all data to the cloud computing center through the network to solve the problems of computing and storage. However, with the popularization and development of the Internet of Things in people's lives, the number of devices connected to the Internet of Things has gradually increased, resulting in a large amount of data. The network bandwidth of cloud computing can no longer meet the needs of time-sensitive systems [2] and real-time. Therefore, the cloud computing model has shortcomings in load, real-time performance [3][4], transmission bandwidth, energy consumption, data security and privacy protection [5].

Edge computing is different from cloud computing. It is a new computing paradigm, which performs computing at the edge of the network. Its core idea is to make the calculation closer to the source of data [6]. Edge computing can not completely replace cloud computing, it is an extension and supplement of cloud computing. Compared with the traditional cloud computing model, edge computing can bring the data processing ability closer to the data source, thus reducing the delay, reducing network pressure, improving data security and privacy, and adapting to the demand of real-time and rapid response.

Although the current landslide monitoring and early warning system has been digitized and automated, the complexity of slope landslide mechanism makes it affected by many factors, which requires multi-factor monitoring and comprehensive analysis. In the monitoring process, there are a series of challenges. First of all, the uncertainty of mountain environment and the limitations of traditional monitoring methods in data transmission and processing make the monitoring work face multiple difficulties. Slope is usually widely distributed, and the number and variety of sensors required for monitoring elements are various, which brings complexity to data acquisition and processing. In addition, different sensor products have different information collection and transmission methods, so the monitoring platform needs high compatibility to integrate this diverse data and ensure the effectiveness and stability of the monitoring system. At the same time, due to the danger of landslides, the monitoring system requires real-time performance in minutes and seconds, and the monitoring platform needs to have fast and efficient data processing and storage capabilities to meet the challenge of massive data. In this context, edge computing has become one of the solutions. Edge computing can

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push data processing directly to the source of data, realize local processing and analysis, and avoid the network connection delay and data transmission bottleneck of traditional centralized processing, thus improving real-time and accuracy. The introduction of edge computing into the field of landslide monitoring is expected to improve the response speed and data analysis ability of the monitoring system.

The traditional slope monitoring platform built by cloud computing technology has many shortcomings: real-time problem, security and privacy protection problem, data storage problem and functional failure to meet the diverse needs of users. In view of the above problems, this paper aims to propose a brand-new automatic monitoring platform for slope to meet the personalized needs of users and provide better monitoring results. The main research contents are as follows: 1) The demand analysis of multi-factor automatic monitoring of slope shows that there are many factors causing landslide, and the same slope may need to be monitored by many types of sensors, and the monitoring units have different monitoring information processing and monitoring point information management, which requires the monitoring platform to be widely compatible. 2) The architecture of multi-factor automatic monitoring platform for slope based on edge computing is constructed. Based on the conceptual model of slope monitoring, a two-level edge computing architecture is constructed, which is based on the cloud control center, sets a controller at the same monitoring point, is responsible for the control of multi-factor monitoring sensors, the control of monitoring sensors and the migration of original data analysis to the controller, and the management of monitoring points and the migration of data characteristic processing and application to the user platform. Through the verification of the actual monitoring project, the automatic slope monitoring platform based on edge computing can reduce the data transmission of edge monitoring sensors and improve the efficiency of real-time monitoring data transmission, and has the compatibility of various instruments and equipment and different personalized users.

## 2. Demand Analysis of Slope Monitoring

The slope monitoring platform is responsible for the interactive affairs with users. Users [7] include ordinary users and administrator users, and ordinary users include managers of government comprehensive departments, government industry departments, owners, equipment manufacturers, monitoring units and monitoring units. The specific operation authority is linked to the user's identity, so that people with different identities can interact with the system.

The platform in this paper is a landslide monitoring and early warning platform, which is used for platform users to monitor the slope status. There are two main bodies in this system: users and slopes. Because the changes of slope status are reflected to users through the changes of monitoring data of sensors, the two entity objects of this system are users and monitoring equipment. In addition to the entity classes derived from entity objects, there are a large number of virtual objects in the system. Here, some classes necessary for realizing the functions of landslide monitoring platform are introduced. The main functions of landslide monitoring platform are monitoring slope, network communication and management information.

Landslide monitoring area has harsh environment, much interference, high risk, large data collection, strong real-time transmission requirements, high reliability and high degree of automation, and the occurrence of landslides is sudden. In view of these characteristics of mountain slope monitoring, the monitoring platform should have the following functional requirements:

Data processing: including data preprocessing, impending slip prediction, data visualization, and ensuring data security. The following figure 1 shows the monitoring data processing function module:

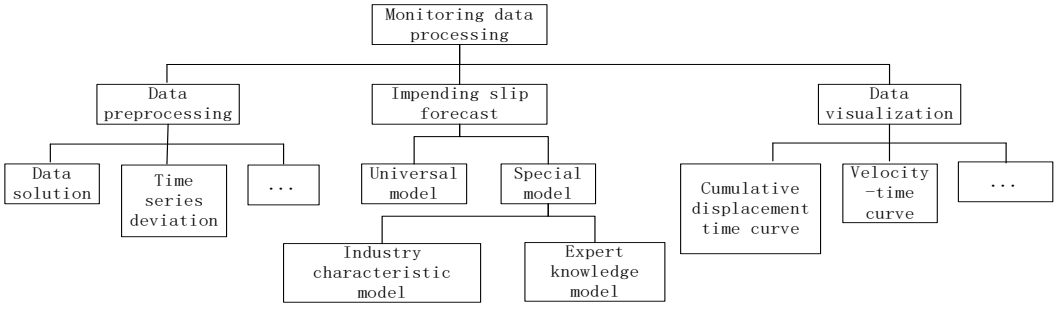


*Figure 1: Analysis of monitoring data processing function*

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Landslide early warning: The analysis and early warning platform should have a certain data analysis and processing ability. By learning the historical data of monitoring parameters, the possible threshold information of slopes can be obtained, and the relevant monitoring data can be comprehensively analyzed and evaluated, and early warning can be made according to the preset threshold, so as to carry out hierarchical early warning for possible landslide disasters. The following figure 2 shows the landslide warning function module diagram:

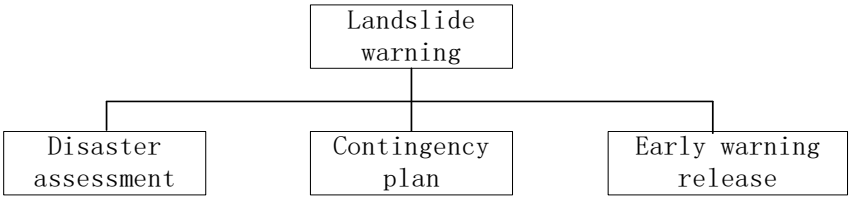


*Figure 2: Analysis of landslide early warning function*

Work site management: users can manage remote work sites in the platform according to its platform, such as work site identification, work site engineering geological information management, work site area analysis, etc. The following figure 3 is the working point management function analysis module diagram:

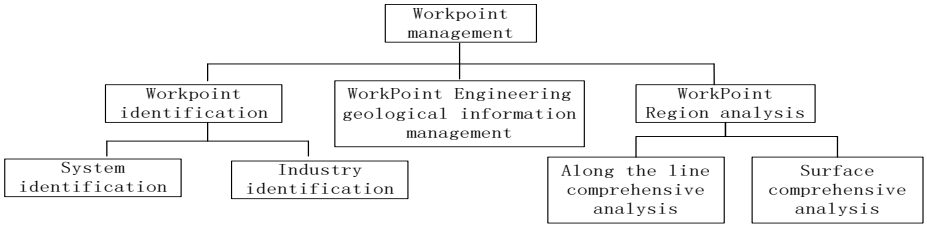


*Figure 3: Analysis of working point management function*

## 3. Construction of Automatic Monitoring System Structure of Slope Based on Edge Computing

### *3.1 Automatic Monitoring System Architecture of Slope Based on Edge Computing*

#### *3.1.1 Conceptual Model of Monitoring System*

The research content of this chapter is the architecture design of slope monitoring system, and the monitoring object is slope. The core requirement of the slope monitoring system is to monitor the slope in real time, collect the relevant data of the slope, and transmit these data to users in the form of graphics and text after a series of processing. The conceptual model of the slope monitoring system is shown in Figure 4:

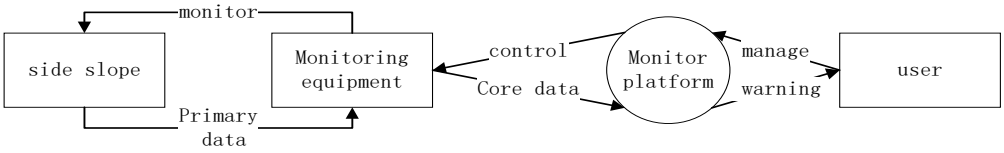


*Figure 4: Conceptual model of slope monitoring system*

#### *3.1.2 Overall Framework of Slope Monitoring System Based on Edge Computing*

The architecture of slope monitoring system based on edge computing is a multi-level edge monitoring system architecture based on conceptual model and demand analysis, aiming at the requirements put forward in Chapter 2. The architecture aims to solve the shortcomings of traditional slope monitoring platform in real-time and data processing, and meet the diverse needs of users. The architecture is shown in Figure 5:

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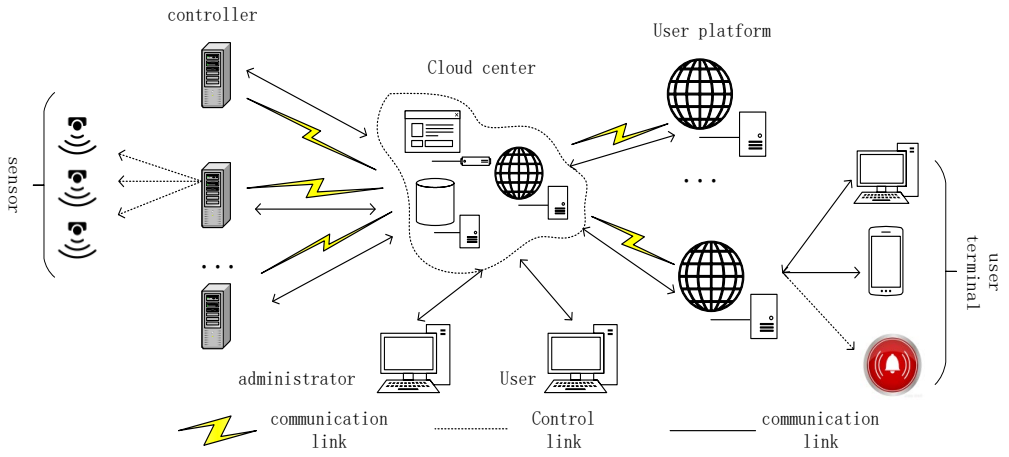


*Figure 5: Architecture of slope monitoring system based on edge computing*

### *3.2 Hierarchical Architecture*

Based on the above-mentioned slope monitoring system architecture, the basic framework of slope monitoring platform based on edge computing is studied [8-11]. Therefore, the data acquisition layer with the controller as the key, the general function layer with the cloud center as the core and the characteristic application layer with the user platform as the key are designed, and the hierarchical architecture is as shown in the figure 6:

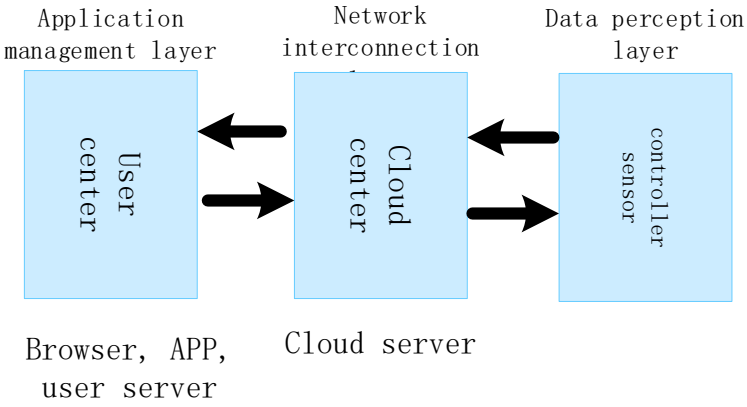


*Figure 6: Edge computing framework*

## 4. Task Migration Based on Edge Computing

### *4.1 Monitoring Data Processing Task Migration*

When the monitoring system needs to undertake many different types of large-scale monitoring projects at the same time, the centralized processing mode puts forward higher requirements for server performance and network stability. In order to overcome these challenges, the controller is added as an edge node in the new architecture proposed in this paper, which can better complete the computing tasks of the cloud center by taking advantage of distance. Specifically, the controller undertakes some tasks of the cloud center, and the cloud center migrates [12] the tasks to the controller, as shown in Figure 7:

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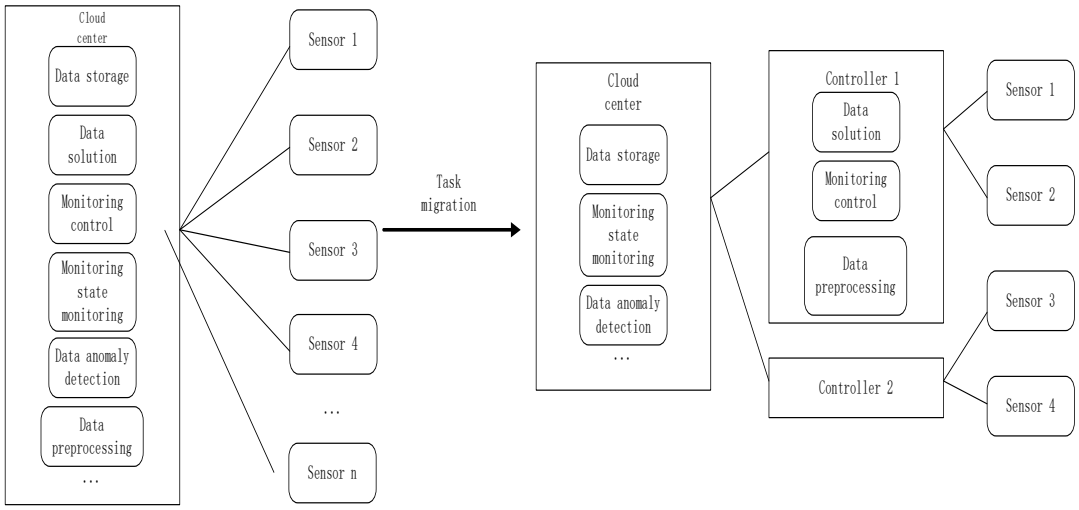


*Figure 7: Controller task migration*

As can be seen from Figure 7, the tasks of migration include monitoring and control, data preprocessing and data solution. In this way, the controller, as an edge node, can directly communicate with the sensor and collect data, and perform data processing and calculation locally.

### *4.2 User Management and Monitoring Management Task Migration*

The user platform is an edge node set up to meet the personalized needs of users, and some tasks of the traditional cloud platform monitoring system are migrated here. The migration tasks include project management, user management, authority management, monitoring methods, data visualization and analysis, and early warning methods, which can be divided into two types of computing tasks, management tasks and monitoring tasks. The task migration is shown in Figure 8:

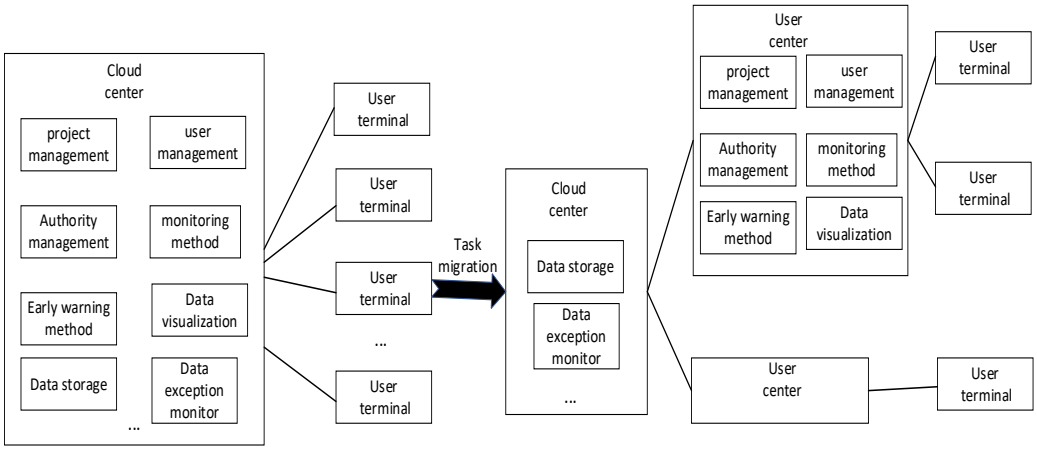


*Figure 8: User platform task migration*

## 5. Conclusions

The platform of this paper was developed in cooperation with Guizhou Traffic Planning Survey and Design Institute Co., Ltd., which is managed and operated by Guizhou Traffic Planning Survey and Design Institute Co., Ltd. At present, the platform has successfully entered the operation stage. There are 39 monitoring projects in different stages, 143 work sites, 493 monitoring points and 402 online monitoring points, with a total of 3,831,838 monitoring data, including deep displacement, surface displacement, tensile displacement, rainfall and groundwater level. The monitoring data of different monitoring equipment all reflect the process from slope deformation to stability after slope treatment, which shows that the local residents can take landslide treatment measures or transfer residents and property in advance through multi-type monitoring of slope and early warning of landslide accidents, thus avoiding casualties and a large number of property losses.

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