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Design of real-time monitoring and intelligent management cloud platform for entire process of construction waste

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Abstract. In order to achieve real-time detection and intelligent control of generation links, transportation processing links, resource utilization and application of recycled products about construction waste, the real-time monitoring and intelligent control cloud platform is studied. This platform can dock urban external construction departments, urban management departments and other external e-government systems to achieve the aims of entire process detection and intelligent resource utilization. This paper studies the design and implementation of real-time monitoring and intelligent control cloud platform for construction waste. This platform is divided into three parts: the data acquisition layer, the data transmission layer, the big data processing layer and application service layer. The article focuses on the functions and technical implementation of each layer: data access design including big data monitoring technology in the whole process of construction waste control, storage design of cloud computing collaborative service technology in the whole process of construction waste control, real-time 3D visualization software and hardware support based on space-time cloud platform.

1. Introduction

Construction waste is a kind of solid waste in the construction, renovation and reconstruction of the construction industry. In the United States, construction work and building are responsible for 40% of the consumed raw materials,40% of the waste desposited in landfills, and 30% of energy-related greenhouse gas emissions[1-2]. About 14 million tons of waste have been put into landfill each year, and around 44% of waste are attributed to the constrcution industry[3]. In Hong Kong, about 13458t soild waste per day were putted into lanffills, and 25% of them is constructon waste. Lu and Tam discussed the difficulties of future garbage management[4]. In 2010 Wimalasena provided a sustainable technique for optimisation of the recycling of construction waste[5]. Construction waste generation is dynamic and interactive. Hao, J. L. find a module to provide a decision support tool for construction waste on-site to achieve better construction and demolition waste management[6, 7]. If we can conduct real-time data-based supervision and control of the entire process of construction waste from generation to utilization, we can effectively optimize the entire consumption chain. Therefore, a system capable of supervising, controlling, disposing and utilizing construction waste in real time is of great significance for resource recycling and environmental protection.

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2. The overall architecture design of the system

From the current research situation, the current regulatory system is supervised and controlled from a certain part of construction waste management[8, 9]. There is a lack of a system for the whole process of the production, construction, and resource utilization of construction waste. Because there are many technical difficulties in this process. First, each link will generate huge amounts of data, such as environmental data, satellite remote sensing data, residual data of solid waste in the source, video data in transit, and air index data in the consumption plant. At the same time, we need to dock the government's urban construction department, the existing management system of the traffic management department. Therefore, in the process of generating, operating, and processing construction waste, the amount of data is huge, and the types of data are also different. So the framework of our system is designed as follows.

The overall technical framework of the construction process real-time monitoring and intelligent management cloud platform (referred to as "construction waste management cloud platform") adopts 'a layered and a modular' design, which is divided into data acquisition layer, data transmission layer, big data processing layer and application service layer.

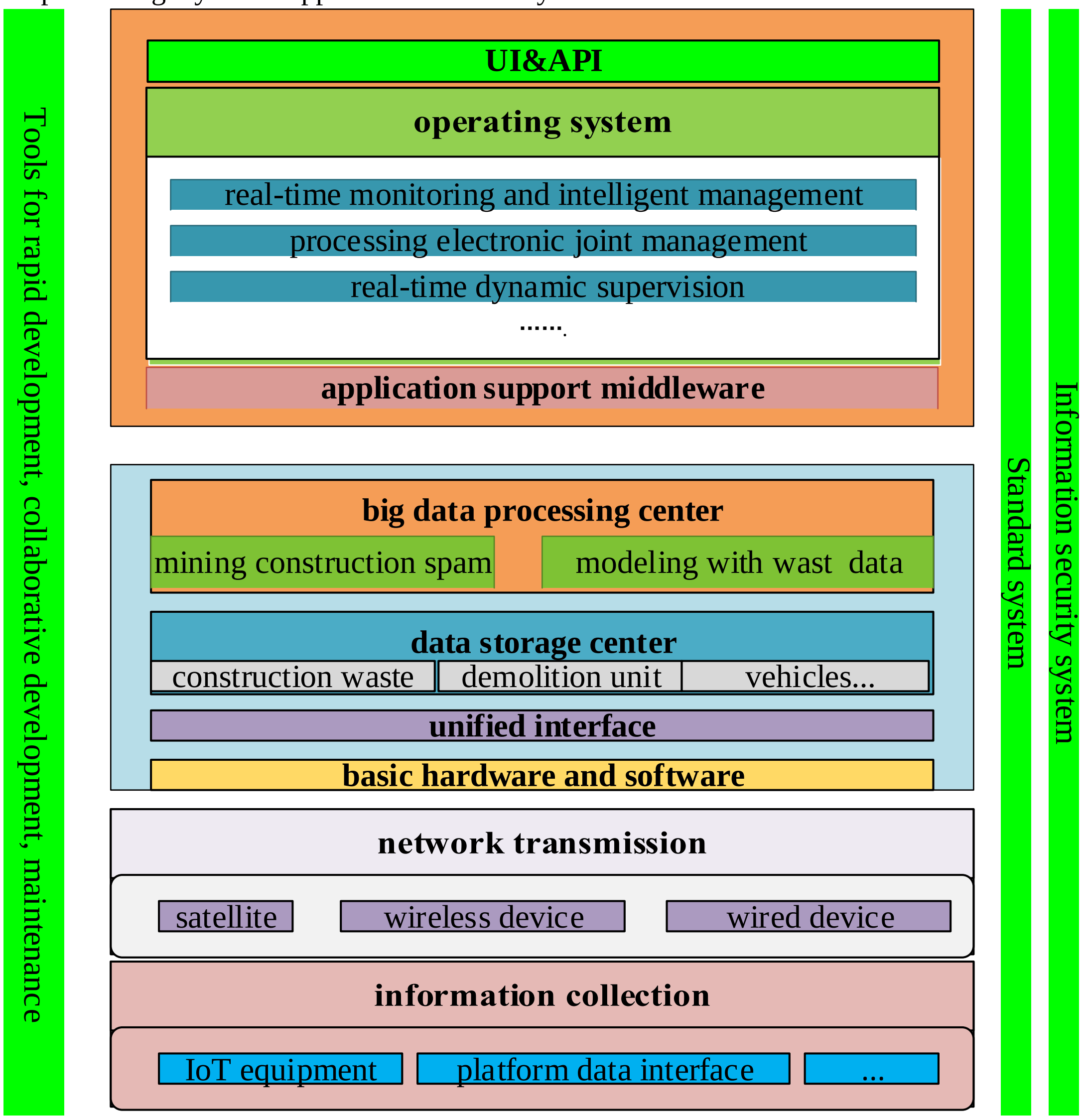

Figure 1 Technology architecture

(1) Data acquisition layer

As the data entry of the construction waste control cloud platform, the data collection layer collects the data uploaded by the IOT device, including the sensory information of various sensors, cameras, IC cards, etc., and we use the intelligent preprocessing technology to intelligently calculate the data. Pre-processing effectively alleviate the pressure of cloud computing, and it can increase the accuracy of calculation. The system can be connected with the government network like the urban management department and transportation administration, WEB service, enterprise intranet and other systems to achieve multi-source data collection. At the same time, our system has an interface to access data from other industries, so it can support multiple applications and services.

(2) Data transmission layer

The collected information like pictures, videos, environmental indicators in construction waste generation source, during garbage transportation, construction waste disposal site is transmited to the processing layer through wired and wireless communication networks in data transport layer. In general, the wired or wireless communication network channels of each communication carrier are leased to implement data transmission. In order to ensure the security of some sensitive professional business data, these data will be transited through private network.

(3) Big data processing layer

Big data processing layer includes cloudized basic software and hardware, spatio-temporal data unified interface, data cloud storage center, and data analysis-processing center.

The data cloud storage center collects data on the whole process of construction waste generation, operation, processing, resource utilization, and recycling product utilization through the unified interface of time and space data, and then converts the data by extracting, cleaning, converting, merging, and aggregating operations in order to standard data format to meet the model and quality requirements of platform data. At the same time, the data is saved to a static file format and a real-time cache format through the data bus. The data loading module provides service data for the service application layer, then the instruction control module can implement instruction transmission and reverse control for the access terminal and the data grid processing module can implement the access of time-space data grid processing to realize fast data. index and location exact lookup.

The data analysis and processing center includes seven sub-modules: business model building, online streaming data analysis, offline massive data analysis, parallel data analysis, task scheduling control, work management control, and intelligent learning system.Through the above modules, a variety of thematic think tanks such as the construction waste information repository, the demolition (construction) unit information base, the construction waste transportation monitoring library, the consumption field information supervision library, the classification and recovery library, the early warning emergency library, and the decision-making repository are formed.

(4) Application service layer

The application support middleware module includes middleware sets such as communication services, business processing services, alarm services, report services, electronic map services, video image processing services, data processing services, mobile application services, security suites. UI/API access refers to the channels and media serving users, including portals, service websites, mobile terminal interfaces, vehicle terminal interfaces, API interfaces, and so on.

(5) Support system and tool set

Support systems and tool sets include standard specification systems, information security systems, operation and maintenance tools, rapid development tools, collaborative development tools, etc.

3. System implementation

3.1. Data Access Design

The data access design adopts the intelligent IoT gateway technology, which is characterized by configurability, flexible, stable and reliable transmission. Its design architecture is shown in Figure 2 including data receiving, data processing, protocol conversion and data reorganization. The platform can integrate the government's existing platform data to ensure system scalability.

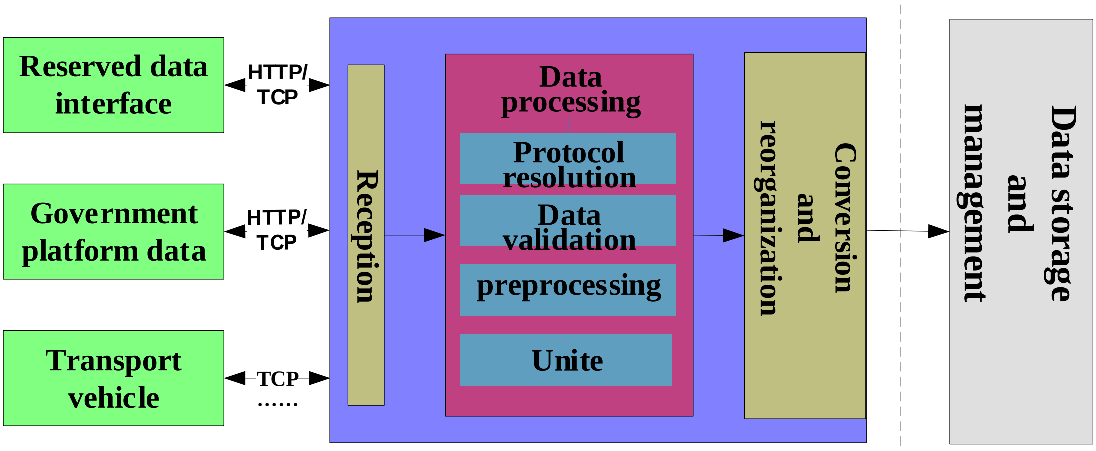

Figure 2 Data access software system schematic

3.2. *Big Data Storage Mamagement Design*

The big data storage management subsystem uses a distributed non-relational database, a relational database and an in-memory database to complete the storage management of various types of construction waste data. The distributed non-relational database and the relational database perform ETL (Extract, Transform, Load) operations on each other to implement data extraction, cleaning, merging, and loading. The relational database and the in-memory database data are exchanged, and at the same time, the in-memory database loads the relational database business data, and the in-memory database stores the result data in the relational database. In this system, the distributed non-relational storage management system selects Hadoop ecosystem components.We select MySQL database clustering as relational data storage management system;.As to memory storage management system, we select Redis database. The schematic diagram of the logical architecture is shown in Figure 3:

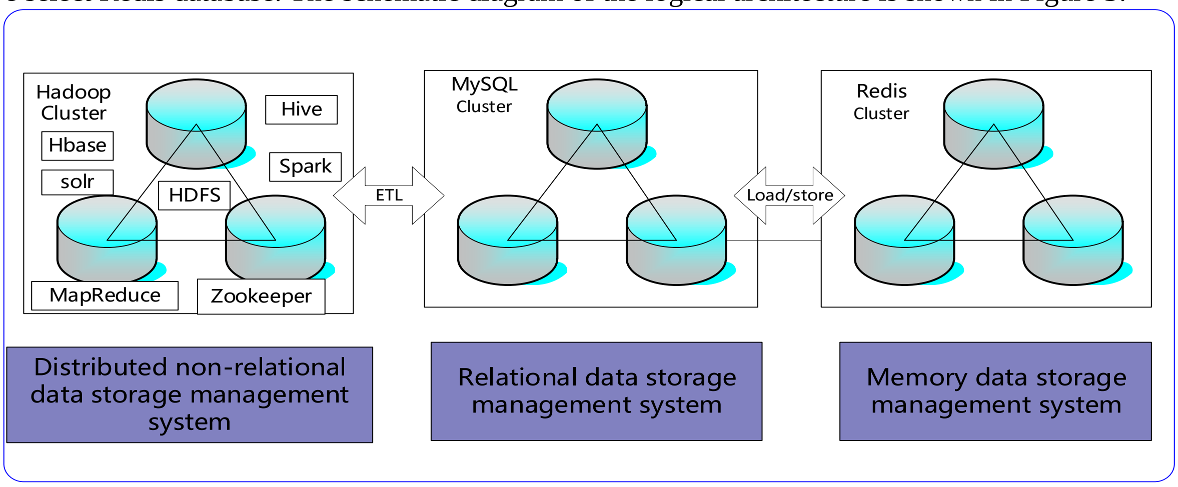

Figure 3 Storage management system

3.2.1. *Technical selection*

In this storage management subsystem, Hbase and other components in the Hadoop ecosystem are selected as the core technology of the distributed non-relational data storage management system in cluster mode. The Hadoop ecosystem components are just like we all known including Yarn, Zookeeper, Hive, Oozie, Mahout, Pig, Flume, Sqoop, and so on.

3.2.2. Design of distributed non-relational data storage system based on Hbase

(1) Beidou time-pace dynamic data and application scenario design

The Beidou time-space dynamic data refers to real-time monitoring data of construction garbage transport vehicles, mainly including the longitude, latitude, time, elevation, speed, direction, status, alarm and other data uploaded by Beidou terminal equipment. Using the Beidou terminal historical track information query, it is possible to query the position change information of a certain vehicle terminal within a certain period of time.

(2) Beidou time-space dynamic data processing and benchmark normalization

First of all we should do something to delete, interpolate, check for invalid data, dirty data and illegal data of Beidou time and space to ensure that the data is effective and complete.Secondly, We also need to perform unified authentication coding on the obtained Beidou terminal equipment data., so that each Beidou terminal device has a system unique ID.Then we should normalize the time and convert the time of different standards into standard time.Finall we normalize the spatial position information, including coordinate system transformation and global mesh segmentation coding. Then, according to "Earth Surface Space Grid and Coding" (GJB8896-2017), we perform global mesh coding for dynamic data.

3.3. Application Software System Design

The application software system includes the following five subsystems:

(1) Real-time monitoring and intelligent management software system

This part mainly conducts real-time monitoring and intelligent control of the source to construction waste. By docking other entry systems we can obtain the location, time, type, composition, total amount of construction waste generation sources, and at the same time real-time it can provide accurate solutions for some problems.

(2) Processing electronic joint management software system

By docking the city management government systems we get data we needed in this part. The main functional modules are: qualification approval, process approval, project progress management, inspection and assessment management, and real-time release of information that needs to be adjusted.

(3) Real-time dynamic supervision for garbage operation vehicles

System data is obtained by docking the construction waste transportation vehicle monitoring system of the urban management department. The main functions of the module include the following monitoring of real-time scheduling of vehicles, monitoring of vehicle implementation, real-time image data of vehicle cameras, real-time query of historical trajectories, decision support for route planning, and for illegal vehicles, it can also be handled on this part.

(4) Rapid identification and monitoring software system

By accessing third-party environment and image data, we can quickly identify, locate, and classify existing heaps in the field. In addition, we can visualize, monitor and warn the environment around the disposal site.

3.4. Platform hardware architecture design

The hardware construction of the platform is based on relevant industry standards, and the existing domestically produced mature hardware equipment is purchased in the market. Therefore, these hardware devices can provide a reliable, stable, fast and compatible hardware platform for the platform software system. The server and the storage array meet the existing requirements in advance, and the special purchases will be made according to the actual situation. The deployment of the hardware adopts virtualization technology.

It consists of two relational database servers, two in-memory databases, three distributed large database clusters, two application servers, one disk array and related network devices.

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4. Conclusion

The construction of the cloud platform realizes real-time online monitoring and processing of the construction waste generation process, transportation process, and disposal process. At the same time, the establishment of the cloud platform provides the possibility of the total production of construction waste, the intelligent dispatch of transportation routes, the prediction of the distribution of landfill disposal plants, and the utilization of construction waste resources. Moreover, the system utilizes intelligent big data collection technology to connect and construct the e-government system of the construction department and the urban management department, and realize the intelligent linkage control of the construction land construction permit and the construction site construction waste discharge permit. The system has high application value and broad application prospects.

Acknowledgments

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