Design of An Intelligent System for Monitoring and Management in Sewage Treatment Plants Based on IoT

Yidai Hong\textsuperscript{1,*}, Hong Liang\textsuperscript{2}, Ruitao Cun\textsuperscript{3}, Yihui Wu\textsuperscript{3}

\textsuperscript{1}Yunnan University, Kunming, China
\textsuperscript{2}Dianchi College of Yunnan University, Kunming, China
\textsuperscript{3}KUNMING DIANCHE WATER TREATMENT CO., LTD, Kunming, China

*Corresponding author e-mail: h646419881@163.com

Abstract. Due to the large number of sources and wide area of domestic sewage, the sewage treatment facilities in Kunming are mainly distributed in scattered market towns and villages and have a wide variety. With the wide application of IoT technology, sewage treatment plants are heading towards intelligence and unmanned technology, with better treatment monitoring, higher treatment quality and lower operation cost. Based on IoT technology, this paper constructed an intelligent system for monitoring and management in sewage treatment plants in Dianchi lake basin and Niulan river basin. The overall architecture of the system was achieved by modularized function design, and was divided into three systems: device end system, network transmission system and application management system. This system realizing centralized management and display can monitor the operating status of sewage treatment process online, improve the efficiency of facility management and operation, as well as the work efficiency of relevant departments. The dilemma related to sewage management in Dianchi lake basin and Niulan river basin can be solved significantly.

1. Introduction

With the rapid development of a new generation of information technology, represented by IoT, cloud computing and mobile Internet, as well as the in-depth application of technical tools such as AI, DM and social network, “smart city” is heading towards a higher stage of intelligent development.

Sewage treatment plants in market towns and villages (sewage treatment plant for short) directly affect the water environment in their basin, resulting in pollution of rivers, lakes and groundwater. With increasing number of these plants, the location has shown a feature of wide distribution and long distance[1]. It is necessary to optimize device end system of each plant and build a complete network...
support structure to meet the actual need. Under the guidance of the Conception of Smart City, the paper proposed a complete monitoring system for sewage treatment plants. Online monitoring of sewage discharge process and relevant devices can be achieved by deploying a variety of sensors and using Cloud-technology[2] to integrate management facilities within the related department by applying the visualization technique, which is a more accurate, dynamic and intelligent method to manage the entire process in the sewage treatment.

2. IoT Technology

IoT refers to the communication between different objects in a certain way, which mainly includes perception technology, communication perception technology and identification technology. As a new generation of information and communication technology, IoT carries out intelligent management between objects based on Internet functions, and features equipment of common objects, interconnection of autonomous terminals and intelligence of universal services[3]. IoT technology is relatively intelligent in management and has a full range of remote identification, reading, interaction and relevant operations.

The IoT system is a networked intelligent computing system integrating the capability of perception, interconnection, computing and control together, which consists of three layer: perception layer, network layer and application layer[4,5]. Based on actual situations, system architecture design scheme should be adjusted according to operating status of different structure levels, combined with advanced information technology.

(1) The perception layer is the foundation of the entire structure and is mainly responsible for relevant data acquisition.

(2) The network layer is used to transmit data securely.

(3) The application layer is the key part of system functionality.

The information obtained from the perception layer will be aggregated to the application layer through private network and processed in the application layer accordingly to meet the actual need.

3. System design

3.1. System Overall Architecture

The system overall architecture is based on a three-tier architecture: device end system, network transmission system and application management system. It is shown in Fig.1.
3.2. System Functional Design

3.2.1. Device End System

Device End System can be divided into three subsystems: water quality monitoring subsystem, operation monitoring subsystem and video monitoring subsystem.

(1) Water Quality Monitoring Subsystem

The water quality parameters (such as COD concentration, ammonia nitrogen, TP, TN, pH, suspended solids and flow) is monitored by water quality automatic monitors. All of data is transmitted to PLC control system and SCADA system so that unattended work site will be truly realized.

(2) Operation Monitoring Subsystem

The operation monitoring subsystem acquires relevant parameters in the generation, treatments and discharges process online by collecting data through intelligent sensors in the key device of wastewater treatment process. Parameters related to operating status of devices and current are transmitted to the operation control cabinet on the spot.

(3) Video Monitoring Subsystem

Based on actual needs of different plants, the video monitoring subsystem installs cameras in key positions such as panorama, major process section and device rooms to monitor the production process. Meanwhile, digital video recorders are installed to capture video signals on the spot, and then images are constantly compared through the video signal recognition system. Alarm signal will be given
automatically once abnormal situation is discovered, which will actively remind the relevant personnel to take measures.

3.2.2. Network Transmission System

All parameters and signals acquired on the spot are summarized into the application management platform by wired or wireless network for data storage, analysis and processing and relevant business application[6]. For sewage treatment plants in market towns, data transmission between field end and center end is achieved by public networks, established by VPN. For those in villages, data transmission between the two ports is achieved by RTU of wireless communication. The firewall is utilized to set security rules, and thus network security systems related to incoming and outgoing network traffic will be monitored and controlled.

3.2.3. Application Management System

The monitoring of the entire sewage treatment plant and relevant business application support are realized through application management platform software. The application software is developed by Java using SQL Server technology.

The application management system can be divided into five application support platforms: the data acquisition and transmission subplatform, the online monitoring subplatform, the operation monitoring subplatform, the maintenance monitoring subplatform and the mobile APP.

1) The Data Acquisition and Transmission Subplatform

In the data acquisition and transmission subplatform, the access management, as well as transmission and configuration of the original data package are achieved through software on the digital water management platform.

2) The Online Monitoring Subplatform

In the online monitoring subplatform, basic functions such as data query, report printing and system configuration are provided by video access and electronic maps to directly view the condition of wastewater discharge.

3) The Operation Monitoring Subplatform

The operation monitoring subplatform adopts a visual way to realize the monitoring in each process of sewage treatment. Thus, accurate support for decision making will be provided for users through intelligent processing.

4) The Maintenance Monitoring Subplatform

The maintenance monitoring subplatform can help users quickly grasp the situation, and relevant affairs including task statistics, operation and maintenance statistics and task reminder are dealt with in time.

5) Mobile APP

Viewing real-time situation of sewage treatment plants, switching facilities remotely and finishing and uploading monitoring record are all available in the mobile APP.

4. The Application Value of the System

1) A Whole Process Monitor

The online monitoring subsystem and the video monitoring subsystem can help users grasp situation on the spot. A variety of functions such as online monitoring, total amount calculation and
production management of pollution discharge situation in these plants can be achieved by connecting the data on the spot to the online monitoring subplatform.

(2) Intelligent Control and Decision Making

Through the analysis of intelligent model in the monitoring system, abnormal problems in the treatment process can be traced, and hereby treatment opinions can be put forward to guide the normal operation of the pollution discharge process. Thus, relevant affairs can be dealt with and work efficiency will be improved.

(3) Pollutant analysis

Through the whole IoT system, the sewage source can be traced and pollution situation evidence can be collected to analyze the reason of pollution and then supply scientific basis of offering for the Dian Lake and the Niulan River of water resource protection.

5. Conclusions

The IoT-based sewage treatment plant monitoring and management system is a complete and feasible intelligent system. In the process of the construction of smart cities, it is of great significance to keep abreast of current situation of environmental pollution utilizing IoT technology for the improvement of the ecosystem.

In the future, the system can be further improved and extended to provide intelligent support for decision-making in time and put forward corresponding measures, using the new generation of information technology such as cloud computing, AI, big data analysis, DM and visualization[7]. The water environment of Dianchi lake basin and Niulan river basin can be improved and intelligent ecological development can be realized.

6. Acknowledgments

This work was financially supported by KUNMING DIANCHI WATER TREATMENT CO., LTD.

References

[1] Shengya Liu. Design and Development of Wastewater Treatment WebGIS Platform in Villages and Towns of Dianchi Lake Basin[D]. Yunnan University, 2018.

[2] Liu Jin, Yu Xiao, Xu Zheng, Choo Kim-Kwang Raymond, Hong Liang, Cui Xiaohui, A cloud-based taxi trace mining framework for smart city Softw. Pract. Exper., 47 (8) (2017), pp. 1081-1094.

[3] Zhaoyu Pei, Cong Gao, Liqun Song. Study on the Development status and tendency of IoT communication technology [J]. China CIO News, 2019(08):46.

[4] Information on https://baike.sogou.com/

[5] Atzori L, Iera A, Morabito G. The Internet of Things: A survey. Computer Networks, 2010, 54 (15): 2787-2805.

[6] Dingfu Jiang. The construction of smart city information system based on the internet of things and cloud computing[J]. Computer Communications, 2019.

[7] Yi Zhao. Application of IoT technology in smart city management [J]. Science & Technology Information, 2019, 17(19): 32-33.