



Overview of water supply operation and maintenance management service system

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Abstract. In order to solve the problems of backward management level, lack of professional and technical personnel, high effluent quality requirements and equipment operation and maintenance management of traditional water supply production enterprises, it is necessary to study a set of operation and maintenance management service system applied to water supply production. The main functions of the water supply operation and maintenance management service system include: monitoring the production process of the water plant, equipment status, water quality parameters, etc., and providing remote fault diagnosis, maintenance and optimization of various equipment and other services. After engineering application, it provides information, convenient and intelligent work platform for the production management services of water supply enterprises, and also expands more professional and faster service capabilities for system suppliers.

Keywords: operation and maintenance management, data processing, network communication, monitoring system

1 INTRODUCTION

In recent years, with the rapid development of urban and rural water supply integration in China, new requirements have been put forward in terms of ensuring the stability of urban water supply and improving the quality of water supply. At the same time, it has also brought new challenges to the production management level of water supply operation and maintenance enterprises and the remote service ability of system suppliers. These new challenges mainly include: low intelligence level of production, lack of equipment operation and maintenance information, low efficiency of generating and transmitting maintenance work orders, and inability to provide professional maintenance and management strategies. Under this condition, based on the results of years of integrated technology research and development and engineering application of complete sets of water supply equipment, combined with the new demand of water supply enterprises for operation and maintenance management services, we have researched and developed this water supply operation and maintenance management service system. On the one hand, this system improves the intelligent level of production management of water supply enterprises, and establishes a massive data and information base for equipment maintenance and maintenance. Greatly improve the level and efficiency

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of production management; On the other hand, the system service providers can provide remote visualized fast service means for water supply production management through the system, as well as professional solutions to solve various problems, thus providing a new management and service platform for water supply production enterprises and their system service providers.

2 SYSTEM ARCHITECTURE

This water supply operation and maintenance management service system is built on B/S architecture (server and browser, local area network), C/S (client and server, wide area network), the hardware configuration mainly includes: Configure host computer, data server, communication networking module, RS232/485 serial port communication module (local device end), terminal computer, mobile phone APP, PAD and other devices. At the same time, according to the actual needs, it is necessary to upgrade or transform the on-site equipment of the water plant, mainly including all kinds of sensors, actuators and PLC, etc., sensors are used to collect various data, such as water level, pressure, flow, pH value and water quality parameters, and actuators are used to control all kinds of equipment such as pumps and valves^[1].

The data link and communication structure are combined with wired and wireless to improve the flexibility and coverage of the system. It mainly includes: data acquisition and control (PLC) + equipment with serial port or Ethernet communication -- networking communication module (4G network communication) -- data processing server (or cloud platform) -- PC terminal, PAD, mobile phone APP, etc. (including system and application software), as shown in Figure 1.

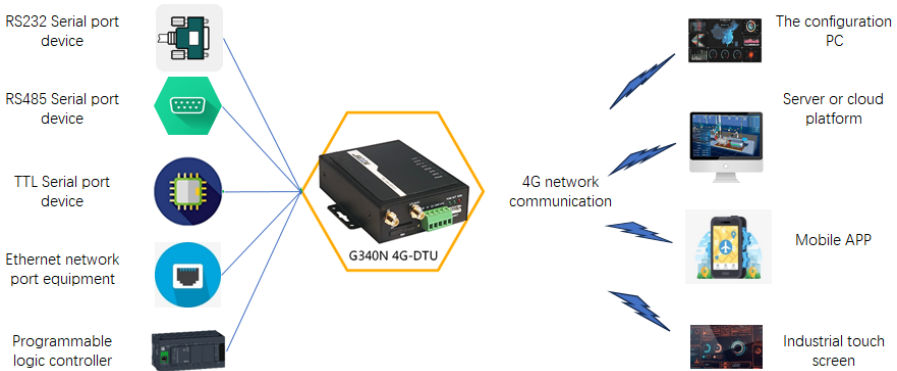


Fig. 1. Data link and communication structure diagram

3 THE MAIN COMPONENTS OF THE SYSTEM

The main components of the water supply operation and maintenance management service system generally include:

3.1 Network communication module

G340N 4G DTU is an industrial-grade serial port/network port to 4G communication networking module. It is 4G full Netcom (7 mode) DTU, supporting Internet of Things card and APN private network.

G340N implements the user's serial port and network port device access to the server software platform through 4G network, supports TCP and UDP communication protocols, and supports transparent transmission of serial port and network data (data content remains unchanged).

Support MODBUS-RTU interconversion MODBUS-TCP protocol function, support the active collection of serial data, and can analyze and combine new data packets and upload to the server through the 4G network. The CPU uses a 32-bit high-performance Cortex-M3 core ARM processor to run a high-performance embedded real-time operating system with fast data exchange and logic processing capabilities^[2].

3.2 Data processing server

The water supply operation and maintenance management service system adopts industrial-grade data processing server (or cloud platform), which is mainly used for real-time communication with PLC, providing data storage and management services, data encryption upload (RSA encryption, asymmetric encryption, double key import) and other functions and services.

The components of data processing server include: high-performance hardware components, such as server equipment, storage equipment and network equipment; And corresponding software, such as operating systems, database management systems, and file systems. The server utilizes advanced storage technologies such as high-capacity hard disk arrays and RAID to ensure high data reliability and high performance. In addition, the server also provides data backup and recovery functions to ensure data security. Supports multiple storage modes, such as block storage, file storage, and object storage. It also allows data sharing by setting permissions and access control. At the same time, a large amount of data can be analyzed to extract valuable information and rules, and an expert system can be formed to support business decisions.

3.3 Remote monitoring configuration software

From the point of view of the master network of the remote measurement and control system, in addition to the necessary system software, based on the characteristics of wireless communication, we have also developed a special communication management, collection management and measurement and control protocol to achieve real-time data collection, storage, analysis and visualization, support the delivery of remote-control commands, and remote configuration and debugging of equipment. Make the measurement and control system more stable and efficient operation. The water supply operation and maintenance management service system can directly communicate with each PLC station and communication equipment through the remote communication module 4G DTU, and its communication channel, equipment and communication

protocol are transparent. Generally, as long as the number of sub-station PLC to be monitored is set in the configuration software, and then the monitoring screen is formed by dragging graphical controls. At the same time, the system configuration and development of the monitoring configuration software also has a powerful drawing function, so that engineers are very easy and fast to draw vector graphics and special equipment composite graphics, support the production of screen background for the map project, support magnification, reduction and drag. The developed configuration software has the characteristics of convenient and friendly man-machine interface and fast operation response.

3.4 Mobile APP configuration software

Mobile APP configuration software can enable operation and maintenance management service personnel to monitor all kinds of on-site status information in real time, and also enable system service providers to receive timely and accurate notifications about equipment maintenance, which greatly expands the convenience and experience of user management personnel and system service providers to carry out various task information and processing. The selected software is an extension of PC configuration software. We only need to select the platform device for software release as mobile phone. Therefore, mobile APP software fully inherits the advantages of PC configuration software focusing on remote measurement and control.

Using the CS framework APP software developed at the bottom of the standard system, not only the page loading is fast and the flow is small, but also the intelligent work order function is input at any time, timely release, local feedback, closed-loop processing and other processes to achieve seamless connection, so that the function of the water supply operation and maintenance management service system can be maximized, the measurement and control is more efficient, and the communication is more stable. At the same time, the software can also automatically identify and update the APP version^[3].

4 SYSTEM FUNCTIONS AND CHARACTERISTICS

The main functions of the water supply operation and maintenance management service system include: remote intelligent measurement and control and data transmission function, equipment life management system, all-round production data display, application of expert database, mobile APP and intelligent report system. The main functional structure of the system is shown in Figure 2.

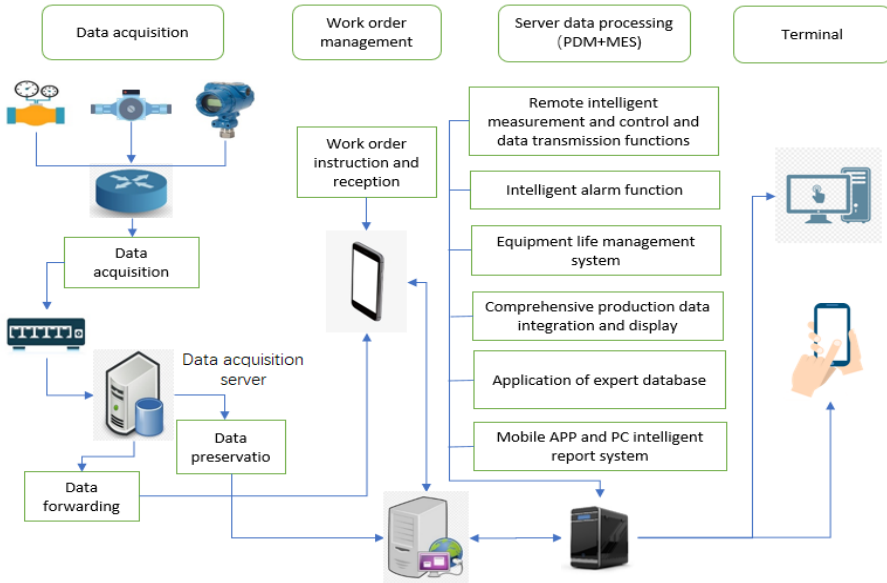


Fig. 2. Main functional structure of the system

4.1 Remote intelligent measurement and control and data transmission function

Through the various equipment units, control units and instrument measurement units of the water supply plant, the PLC is used for data measurement and control and processing, and then through the measurement and control ports covering various industrial communication methods (including serial ports, Ethernet ports, etc.), remote communication modules, network communication networks, data servers and monitoring software, etc. It can realize the integration of remote measurement and control of various on-site measurement signals and data by operation and maintenance management services, including the collection, processing, storage, event, report and alarm disposal of measurement signals and data, and form a management closed loop of data transmission and processing feedback.

4.2 Equipment life management system

The whole life management of equipment includes the whole process of installation, use and maintenance of equipment during the service cycle, including the storage of equipment file data and the recording of the use process, etc., which is an important work in the operation management of water supply production units. The water supply operation and maintenance management service also extends the registration and inquiry of the spare parts model, quantity and special tools of each equipment^[4]. It is convenient for equipment management personnel to carry out maintenance work quickly. The whole life management of equipment management is combined with the

daily equipment maintenance work, and the platform automatically records and stores, which is convenient for managers at all levels to read and view^[5].

4.3 Comprehensive production data integration and display

Home page	▲	Total daily inlet flow (m ³ /h)		Real-time discharge flow (m ³ /h)		Real-time equipment energy consumption (KWh)	
Basic data management	▼	169951		16331		3921	
Plant and station management	▼						
Production management	▼	Effluent quality parameter			Removal rate		
Warehouse management	▼	Turbidity (NTU)	Residual chlorine (mg/l)	NH ₃ -N (mg/l)	No.1 filter (%)	No.2 filter (%)	No.3 filter (%)
Expert knowledge base	▼	0.05	0.66	0.01	89.23	86.50	83.03
Statistical statement	▼						

Fig. 3. Comprehensive production data display

Water supply production units need to comprehensively and accurately collect and display equipment signals, instrument signals, process data, operating parameters, etc. involved in production, generally including water quantity, water quality, drug consumption, reduction amount, flow charts, process information, equipment information and task information, as shown in Figure 3. All the production situation of the project is displayed in one interface at the same time, which is convenient to query, check, deal with and summarize various production problems. At the same time, it has independent information display of individual plants and stations, which is convenient for technical and management personnel to quickly query, real-time grasp the operation dynamics of each plant and station, and can integrate the existing enterprise resource planning (ERP), asset management (CMMS) and business intelligence (BI) systems to achieve seamless docking of information flow.

4.4 Application of expert database

The system can also provide operators and maintenance personnel with the necessary training to ensure that they can use the system proficiently. At the same time, establish a technical support system to solve the problems encountered by users in the process of use.

In the process of operation and maintenance management services of water supply production enterprises, an expert database system similar to a think tank can be formed through years of data accumulation and fault handling mode, including various

knowledge of process production, equipment maintenance, safety training, and personnel management. Once the system receives conventional process anomalies, water quality fluctuations, equipment failures or work order instructions, the system will automatically match expert suggestions for treatment and recommend them to operation and maintenance personnel for selection and treatment. At the same time, the system can also include the information of technical experts in the industry and within the company into the expert database, when the technical problems that are difficult to solve in the process of water supply production or operation and maintenance, you can ask the experts by email, so as to obtain a better solution^[6].

4.5 Mobile APP and PC intelligent report system

The human-machine interface of this water supply management operation and maintenance service system is friendly, so that operators can easily monitor the system status, receive alarms and take appropriate actions. The data measured and controlled by the system (such as water quantity, water quality, operation status of key equipment, energy consumption, etc.) are extracted and transmitted to the PC or mobile APP in real time, as shown in Figure 4, which not only allows the manager or operation and maintenance personnel to know the operation status of the equipment anytime and anywhere, but also enables the system to query various production data, with easy operation and simple interface. At the same time, through the data collection, classification, analysis, summary, storage, etc., the intelligent report system is generated, which has three functions: automatic report generation, manual input report and manual/automatic combination report generation. Combining the advantages of automatic report generation and manual input report, data recording, storage, display and printing can be realized on the same report according to the data source, calculation formula and generation time^[7]. The intelligent report system not only reduces a large number of production data summary, analysis, filling in the workload, but also effectively avoids human error and time delay in the statistical process, and greatly solves the pain points of large data volume, many types of reports, and complex statistical work on the project process operation.

Data 2023/11/1																			
Time	Water intake pump house		Water supply pipeline		Effluent quality					No.1 Feed pump		No.2 Feed pump		No.3 Feed pump		No.4 Feed pump		Active power (KW)	Reactive power (kvar)
	Liquid Level (m)	Pressure (MPa)	Flow rate (m ³ /h)	Pressure (MPa)	Turbidity (NTU)	PH	residual chlorine (mg/l)	NH ₃ -N (mg/l)	Total manganese (mg/l)	Voltage (V)	Current (A)	Voltage (V)	Current (A)	Voltage (V)	Current (A)	Voltage (V)	Current (A)		
0:00	6.8	0.322	12731	0.35	0.06	7.52	0.69	0.00	0.005	9905	70	9893	69	9912	0	9891	37	3556	977
1:00	6.83	0.322	11822	0.32	0.06	7.54	0.72	0.00	0.005	9941	71	9933	70	9956	0	9935	38	3478	971
2:00	7.45	0.321	10540	0.30	0.06	7.53	0.73	0.00	0.010	9950	71	9945	0	9964	0	9944	38	2259	650
3:00	7.45	0.322	10005	0.31	0.06	7.52	0.72	0.00	0.010	9945	70	9939	0	9960	0	9937	37	2189	636
4:00	7.45	0.323	9908	0.31	0.06	7.50	0.71	0.00	0.010	9950	69	9940	0	9959	0	9937	37	2093	603
5:00	7.45	0.322	10184	0.31	0.06	7.50	0.72	0.00	0.010	9962	70	9952	0	9974	0	9956	38	2212	634
6:00	7.46	0.321	11422	0.30	0.06	7.50	0.71	0.00	0.010	9958	69	9949	70	9971	0	9951	38	3341	938
7:00	7.28	0.320	13769	0.33	0.05	7.49	0.66	0.00	0.009	9872	70	9865	68	9882	0	9864	37	3576	1001
8:00	6.82	0.320	15602	0.39	0.05	7.47	0.62	0.00	0.009	9896	69	9885	69	9905	0	9884	36	3730	1045
9:00	6.84	0.319	16026	0.40	0.05	7.46	0.62	0.00	0.007	9888	70	9879	70	9896	0	9877	36	3842	1067
10:00	7.02	0.320	15847	0.39	0.05	7.45	0.65	0.00	0.007	9878	70	9869	71	9887	0	9865	37	3611	1005
11:00	6.95	0.320	15764	0.38	0.05	7.45	0.64	0.00	0.008	9865	71	9857	70	9863	0	9853	37	3747	1041
12:00	6.88	0.319	16331	0.40	0.05	7.47	0.62	0.00	0.006	9907	70	9895	69	9910	0	9892	36	3823	1062

Fig. 4. Intelligent report system

5 CONCLUSION

The development of this water supply operation and maintenance management system has established a more information, professional and intelligent maintenance and management service platform for water supply production enterprises, improved the real-time and convenient level of operation and maintenance management, timely reminded users to avoid potential failures, and helped users improve energy utilization efficiency. From the analysis of the situation since the system was put into trial operation, it has brought many new changes to the production management and operation maintenance of the current water supply enterprises. The main changes include: all kinds of production data and information are displayed in real time, alarm information is sent and reported in time, maintenance work orders are generated quickly, and all kinds of report information is more accurate and complete; The system can also call all kinds of equipment maintenance data in time to generate expert optimization suggestions, which greatly improves the management level and decision-making efficiency^[8]. On average, the time to troubleshoot has been reduced by about 30%, the number of operation and maintenance personnel has been reduced by about 20%, and the operating and management costs of water supply producers have been reduced by about 12%. At the same time, the system also prevents unauthorized access and data leakage through data encryption, access control and network security protection measures, and the security of the system operation is greatly improved. The application prospect of the system is broad.

REFERENCES

1. Ma Xiuli, Li Yuan, Yang Zuyue, Zhang Gang, Yu Huixuan, Water treatment equipment monitoring and operation and maintenance system based on industrial Internet platform. *China Instrumentation*, 39-42, No. 9 (2022).
2. G340N Ethernet 4G-DTU User Manual, Beijing Jiemai Communication Equipment Co., LTD., <http://www.sa68.com>,(2020).
3. Technical specification of Ai-Water Artificial Intelligence Management and Control platform, <http://www.devon-tech.com>,(2021).
4. Wu Mingyong, Wu Mingliang, Zhang Rui, Design and application of remote monitoring system of water supply network. *Automation and Instrumentation*, 20-23, No. 10 (2023).
5. Li Cong, Dai Congcong, Feng Yang, The invention relates to an intelligent management and maintenance scheme of urban underground drainage pipe network, *Urban Survey*,185-187, S1(2023).
6. Yazhen Zhou, Qiyao Shao, Zhengming Gu, Research of Urban Residential Secondary Water Supply Management Model, *Water & Wastewater Engineering*, pp. 23-26,38 (2012).
7. Smart Water Supply Solutions, <https://www.haocang.com>,(2023).
8. Liu Xiaoyue, Wang Teda, Wang Xingnan, Ma Weining, Wang Qijia, Research on remote monitoring technology of wastewater treatment plant based on Industrial Internet of Things, *Electric Transmission*, 60-64,71, No. 11(2020).

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