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Ship Cargo Compartment Environment Measurement and Control System Based on SSM Framework

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Abstract. In order to reduce the cargo damage during the transportation of ocean-going ships and ensure the safety of ship personnel entering the cabin, a ship cargo tank environment monitoring and control system based on SSM framework is proposed. The high-precision sensor is used to collect the environmental information in the cargo hold of the ship, transmit it to the local client, integrate the Socket monitor interface into the SSM framework, establish the communication between the local client and the cloud server, and realize the environmental parameter detection and exhaust control of the cargo hold of the ship. The Web project development model using MVC software architecture makes the ship cargo compartment environmental monitoring and control system more convenient in storage and display. The test results show that the system can effectively monitor and control the environmental parameters of the cargo tank of the ship.

1. Introduction

During the ocean transportation of ships, the air humidity at sea is extremely high. The environmental parameters in the cargo compartment change with various conditions such as season, weather and cargo. Keeping ventilation can reduce the temperature of the cabin, and also reduce the humidity of the cabin and avoid the water vapor. Condensed water has a significant impact on the quality of the shipment. In addition, when transporting special items, the detection of harmful gases such as carbon monoxide and carbon dioxide provides safety for ship personnel to enter the cargo hold. If it is not exhausted and treated in time, the accumulation of combustible gas to a certain extent will cause an explosion [1]. Damage to the ship and its staff will cause a large loss to the shipping company.

In recent years, the technology of Internet of things has been developing, and the measurement and control technology of ocean cargo holds has been deeply studied. Since Gao Jianping studied the temperature and humidity of the ship cargo hold, Zhang Qi used the numerical simulation method to design how to discharge the cargo compartment of the ship, but it does not explain the collection of the environmental parameters of the ship's cargo hold and how the data information is transmitted [2]. Li Hongna used wireless transmission in the cargo hold of the ship to detect and record the distant temperature, but there are major limitations in monitoring display and wireless transmission through obstacles [3]. Lu Guobin used ZigBee and GPRS technology to realize remote monitoring of methane gas in the cargo tank of coal transportation ships, but the system did not elaborate on how to remote control [4].

Therefore, this paper designs a ship cargo hold environment monitoring and control system, collects environmental data by placing nodes in the cabin, and transmits the data to the client, establishes a cloud server to client monitoring mechanism, and uses the access server method enables the shipping company and the ship's crew to monitor and control the environmental parameters of the ship's cargo hold.

2. System Design

2.1. System Function Analysis

In the design of the ship's cargo hold compartment environmental monitoring system, including the cargo hold environmental parameter detection display and ventilation and ventilation control. The detection of environmental parameters shows that the internal environment of cargo hold is used to detect acquisition nodes, communication between nodes and clients, client module system and server structure. The ventilation function of cargo hold is controlled by an electrical switch composed of single chip microcomputer and relay to control the operation of the fan in the cargo hold.

The system needs to complete three tasks: first, the establishment of multiple cargo cabin environment collection nodes and the ship client, the application of bus transmission technology to realize the linkage between the environment acquisition node and the client. Second, build an application server mechanism to receive client requests and develop Web and APP applications for shipping companies and ship staff. Third, the application of optocoupler relay and AC trigger can separate the single chip microcomputer from the cargo compartment fan circuit, and increase the security by controlling the strong electricity by weak current.

2.2. System Design

The system is divided into three parts: application layer, cargo compartment environment sensing layer, ventilation and physical control layer, as shown in Figure 1. In the environment perception layer, the nodes composed of the precise sensor group and the microcontroller collect the environment information in the cargo compartment and transmit it to the client. In the physical control layer, the microcontroller transfers signals to the relay module, and controls the cargo cabin ventilation system by using the relay on-off. In the application layer, the Web application system and the server monitoring mechanism are constructed. By receiving the connection requests of the Socket client, establishing connection, data parsing, storage and other technologies, the ship company and the shipboard staff can access the server through the PC and APP terminals, the ship company and the ship staff can keep watch on the ship's cargo hold environment parameters and the control of the ventilation system.

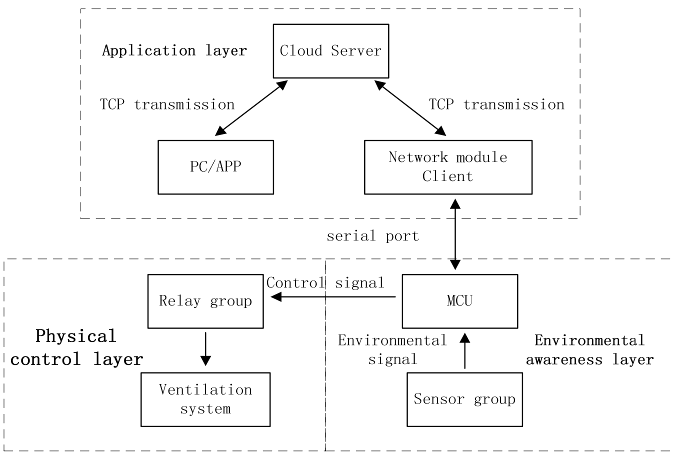


Figure 1. System overall design structure

3. Key Technology

3.1. Ship Client Establishment

The ship's cargo compartment is large and the internal structure is complex. When the environmental parameter collection node is designed and the network client is established, the node distribution, node and client communication problems need to be considered. The system uses a combination of a single-chip microcomputer and an ESP8266 network module to form a client. Compared with the method of directly embedding the WebSocket protocol into a microcomputer [5], the design is simpler, more efficient, and more economical. Although the radio frequency transmission communication is more flexible in use and saves wiring work, it is weak in the ability to cross obstacles, and the internal compartment of the cargo compartment of the ship and the placement of the goods make the wireless transmission mode extremely unstable, so the environment in the system The parameter set node and the client use the CAN bus to transmit to ensure the stability of data transmission [6]. After establishing communication with the node, the client initiates initialization, sets ESP8266 to Station mode, and the data link layer connects to the ship's route, obtains the client's IP address, performs network configuration, and establishes TCP by accessing the cloud server IP and port number. Connected to send and receive data. The client workflow is shown in Figure 2.

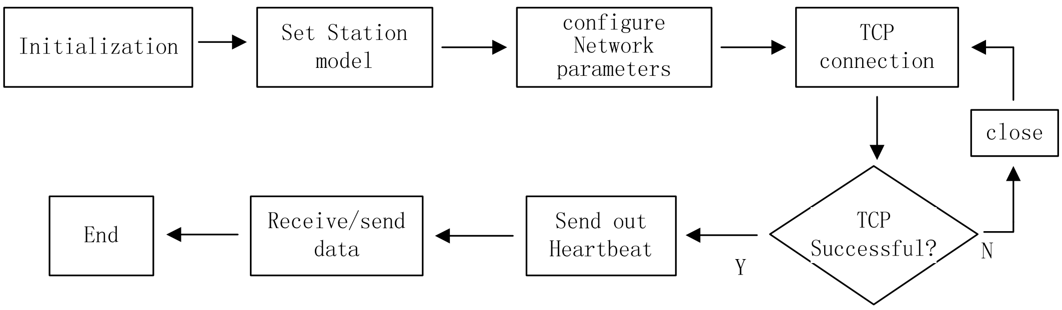


Figure 2. Client module work flow chart

3.2. SSM Framework Fusion Socket Monitor

The server development in this system is designed by SSM framework. As an enterprise application development framework, it has better performance in application service and data processing, but this system needs to establish Socket service during server startup process, and always monitor the client's request on the ship. Connect and receive the Socket packet sent by it. In the SSM framework, Listener is a Servlet listener that listens for method calls or property changes of an instance object. When the listener object has the above event, a listener method will be executed immediately. After the client configures the network parameters, the TCP connection is set up to the server, so a listener of the listening client is fused on the server side. And add the configuration file < listener-class > com.hu.temp.socket1.ServerSocketListener </listener-class> in the web.xml file of the SSM framework, and then merge the Socket listener into the SSM framework. Join the multi-threading mechanism during the period, the server puts the processing flow into a separate thread after each client connection request is received, and then waits for the next client connection request, thereby eliminating the blocking of the server-side receiving request. Achieve multiple ship shipping environment parameters to the server.

3.3. Mobile Terminal Development

The system adopts the mobile WebAPP front-end framework design in the development of user APP. The diversified development method including HTML, CSS and JavaScript technology makes WebAPP have better interactivity, and the advantages of one-time development and multi-platform application can eliminate the difficulty of project transplantation and development, the problem of long development cycle .With MUI as the UI layer, DCloud as the middleware layer, and Android and IOS as the terminal system layer, the mobile WebAPP is slow to run and can't compare the experience of the native APP. MUI does not encapsulate the Dom operation, does not require JavaScript to parse the HTML tag during runtime, reduces the consumption of mobile resources, and speeds up the page loading speed, making the system switches between the ship cargo compartment detection and setting environmental parameter threshold page more smoothly, and the speed is more stable when accessing the server cargo compartment environment data.

4. System Implementation

4.1. Application Layer

The ship cargo compartment environment measurement and control system adopts the SSM framework technology in application layer development, has better access performance and rapid development capability, and is the preferred combination of Web application development framework [7]. The system adopts the MVC software architecture model on the access storage. As shown in Figure 3, the model separates the control layer of the data from the presentation layer, facilitating the subsequent maintenance and expansion of the program, and making the reuse of some programs possible, improving the efficiency of development [8]. Under the framework of SSM, the data stream is read and written to the connected client through the establishment of the input and output stream, and the data interaction of the front and back background Json is realized by using the ResponseBody and RequestBody annotations. The environment parameters of the ship cargo hold are updated with Ajax technology without reloading the whole page. Thus making system application access development. APP uses MUI open source framework design to transmit data by accessing server address and port number to reduce the complexity of the program.

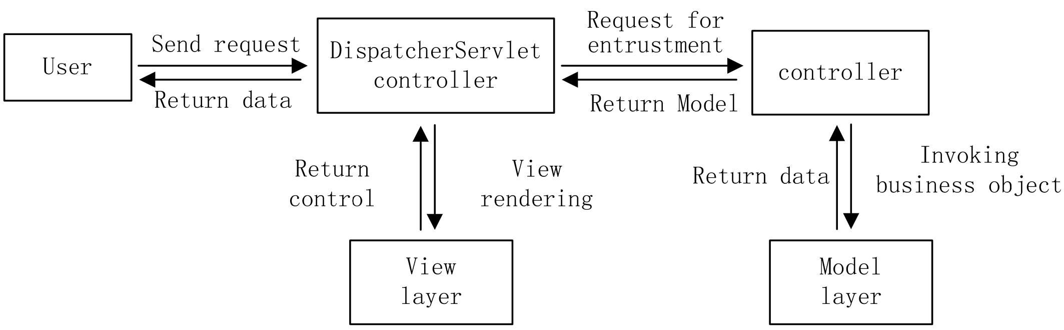


Figure 3. MVC design pattern

4.2. Cargo Environment Awareness Layer

The system uses multiple node designs in the collection of cargo tank environmental parameters, and the nodes are placed in the cabin according to the actual conditions of the goods transported by the ship. Each acquisition node is composed of Arduino MCU plus sensor group. The Arduino core processor is ATmega328. It has 14 digital input/output ports (6 of which can be used as PWM output) and 6 analog inputs. It has good performance in information collection [9]. The sensor group is composed of DHT22 temperature and humidity sensor, MQ-7 carbon monoxide detection sensor and MH-Z19 carbon dioxide detection sensor, as shown in Figure 4.

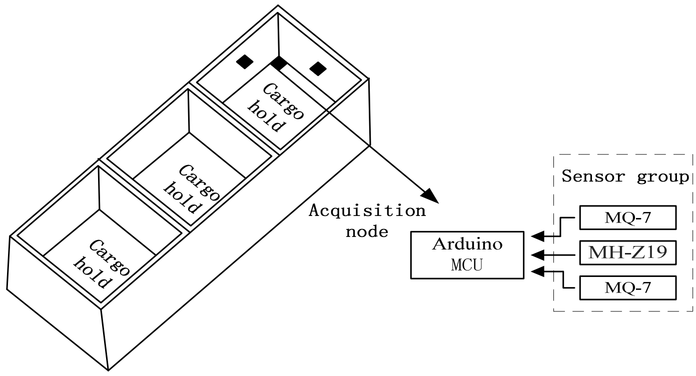


Figure 4. Schematic diagram of cargo node

The node is connected to the CAN bus using a combination of the MCP2515 controller chip and the TJA1050 transceiver. Through the Arduino SPI interface and MCP2515 chip to form a CAN controller, and then according to the CAN protocol for data encapsulation, and finally through the transceiver to achieve bus data transmission, as shown in Figure 5. The number of nodes and the type of sensor are determined according to the actual situation, and the collected cabin environment parameters are sent to the cloud server through the client.

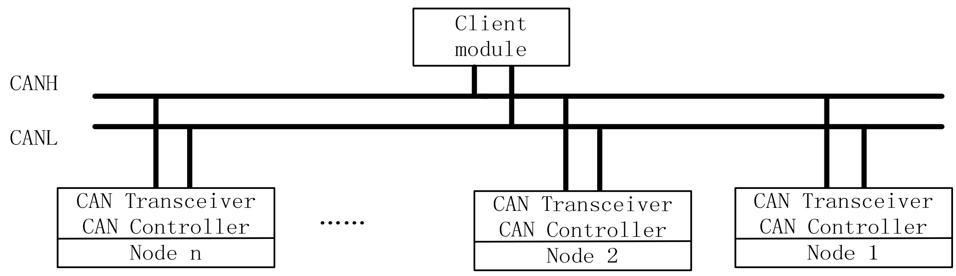


Figure 5. Design diagram of node communication

4.3. Physical Control Layer

The physical control layer is an important part of the ship cargo compartment environment measurement and control system. Its own stable and accurate operation response plays a vital role in the normal operation of the system. Because the working voltage of the ventilation motor in the cargo compartment of the ship is large, it is very dangerous to directly control the switch of the ventilation motor by the single-chip microcomputer. Therefore, the system uses the optocoupler relay to control the suction of the AC contactor to achieve the effect of indirect control.

After the shipping company or the ship's staff sets the upper and lower limits of the cargo compartment environmental parameters, when the cargo compartment environmental parameters exceed the set value, the output signal of the microcontroller is output to the optocoupler relay. The conduction of the field effect tube is controlled through the reception of light and photoelectric elements radiated by its internal light-emitting diodes, and then the AC contactor is triggered to indirectly control the operation of the cargo hold fan equipment.The work flow chart is shown in Figure 6.

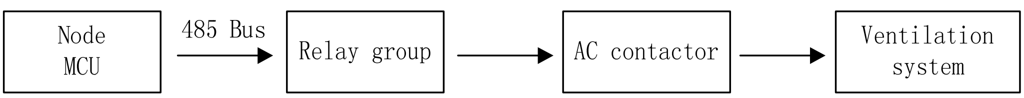
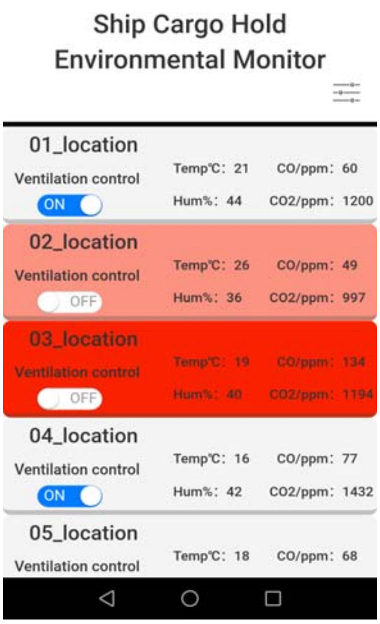


Figure 6. Ventilation equipment control system diagram

4.4. Access Test

The ship cargo compartment environmental parameter measurement and control system uses five information collection nodes in the test phase, and each node is represented in the terminal as a location point. The cargo data of the ship can be accessed in both the PC and the APP, and the depth of the color indicates the excellent state of the environmental condition, as shown by the 02 position point and the 03 position point in Figure 7(a). The increase and decrease of nodes and the upper and lower limits of the ship's cargo tank environment parameters can be well adapted to the number of ship's cargo hold to be tested and the appropriate environmental conditions required for transporting goods, as shown in Figure 7(b).



(a) Ship cargo hold monitoring display

(b) Cargo environment parameter alarm limit setting display

Figure 7. User terminal display

5. Summary and Prospect

In this paper, the Socket interface is integrated into the Web development framework, and a kind of ship cargo hold monitoring and control system based on the SSM framework is constructed. The system enables the ship staff and the ship company to check the environment parameters of the cargo cabin in real time, and can control the environmental parameters in the cargo cabin by setting the upper and lower limits of the parameters, thus increasing the safety of the ship in shipping and reducing the loss in the process of cargo transportation. Thereby increasing the safety of the ship in shipping and reducing the loss of goods in the transportation process.In the future research, we can introduce the expert system or the modeling based on the historical data, use the fuzzy algorithm to carry on the intelligent control. The application layer development introduces the technology of load balancing and distributed processing high concurrency to solve the problem of large access to the system.

Acknowledgments

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