Application and Research of Elevator Internet of Things --Lifting Robot Using Elevator Scheme

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Abstract. To satisfy the demand of the handing robot using elevator in automatic workshop, we had finished the communication between the control system RCS of the elevator and the handling robot based on Modbus TCP protocol, so as to realize the interaction between the control robot and the Elevator Internet of Things system. The research of this paper provides a solution for the access and application of the handling robot in the Elevator Internet of Things, which solves the problem of the handling robot in the elevator up and down, and provides a new way for the material transportation efficiently in the three-dimensional industrial plant.

1. Introduction

In the modern production workshop, the human cost is higher and higher, compared with the traditional artificial, the industry robots have a nature advantage in doing some drab, frequent and repetitive job for a long time in the industrial production, and traditional artificial robot has become the inevitable trend in the labor intensive industry. At the same time, the average failure interval of industrial robots is more than 60000h, which can improve production efficiency and ensure product quality, save labor, provide a safer working environment, reduce labor risk, and replace traditional labor has become an inevitable trend [1]. For the material transportation in the production workshop, the autonomous navigation and handling robot has been born for more than 60 years, and its technical ability has made great progress. It is widely used in many fields such as warehousing, manufacturing, transportation and so on [2]. In the environment of multi-story factory buildings, the robot is a horizontal transportation tool, and the elevator is a vertical transportation tool. To realize the effective combination of horizontal transportation and vertical transportation, robot and elevator formed a complete transportation system for production workshop, which solve the communication of robot and the elevator, this paper discusses the interaction possibility between the control handling robot and the elevator IOT system.

2. Methods and technical route

2.1. Methods

We used one Shanghai automation workshop application requirements for example, as the workshop of the elevator service life is long, so we proposed that do not change the elevator control system of the original electric circuit in order to prevent the transform the aging line signal interference which
would lead to instability of elevator running. All the elevator status signal and robot command signal that we required should be connected used in the outside implementation.

We decided to use PLC and PC two ways to achieve elevator system control. Although PC was introduced into the control industry, but PLC is still in continuous development, and did not quit the stage, this is because it can be combined with new technology quickly, such as a large number of network connections, processing speed, local storage and programming flexibility and other technologies. Another reason is that the integration of various control modules has no compatibility issues, which reducing start-up and system validation costs, providing a well-tested and stable control environment. PLC made of microelectronic technology, it is also composed of CPU, RAM, ROM, I/O interface and other 5 pieces, which has the similar structure to microcomputer. Different from the general microcomputer (see Table 1), it uses special anti-interference technology which makes more suitable for industrial field control under harsh environment. Modbus is a serial communication protocol published for PLC communication, which is now a common connection mode used in industrial electronic equipment.

| Table 1. Difference between programmable control equipment and microcomputer. |
|------------------|------------------|------------------|
| **Project comparison** | **PLC** | **PC** |
| Range | Industrial control | Scientific computing, data processing, communication, etc |
| Environment | Industrial site | Room equipped with a certain temperature and humidity |
| Input/output | Photoelectric isolation is required to control strong current equipment | Micro electric contact with the host without photoelectric isolation |
| Design | Generally for ladder diagram language, easy to learn and master | The program language is rich and complexed, including assembly, FORTRAN, BASIC and COBOL, which need specialized computer hardware and software knowledge |
| Function | Self-diagnosis, monitoring, etc | Equipped with a strong operating system |
| Method | Cyclic scanning mode and interrupt mode | The interrupt way |

Modbus/TCP is a derivative of ModBUS, which is used by neutral vendors to manage and control automation devices. Obviously, it covers the use of MODBUS messages in "Intranet" and "Internet" environments using TCP/IP protocol. The most common use of the protocol is for services such as PLCs, I/O modules, and gateways that connect other simple domain buses or I/O modules. In this method, the Modbus client initiates a TCP/IP connection with the Modbus server. After the connection is established, the client makes a request to the server, and the server responds to the client's request.

Therefore, in this system environment with higher stability requirements, according to user requirements, we conducted tests on PLC data communication mode. According to the test results, we took PLC as the Modbus TCP server, and the robot scheduling system RCS (hereinafter referred to as RCS) actively established TCP connection with PLC. The RCS system queries the elevator status to PLC regularly, and the RCS sends elevator control instructions to PLC regularly to realize the communication between the elevator control system and the RCS[3].

### 2.2. Connection between PLC and RCS

RCS will not directly read and write PLC digital input and output through Modbus TCP protocol, but in PLC programming, the PLC digital input state value and digital output state value are saved in the
hold register, Modbus TCP client service in PLC will save the data. The data of the hold register is regularly fed back to the RCS system with 03 command, and the instruction of the RCS to the elevator is also indirectly reached to PLC by writing the hold register with 10 command, so as to realize the interaction between the RCS control robot and the elevator, and the robot can go up and down with the elevator. Therefore, PLC should reserve enough digital quantity input points and digital quantity output points to collect elevator state signals and issue instructions. The system structure is shown in Figure 1[4].

![Figure1. System structure](image)

1) PLC gives five digital input points in order to correspond to the magnetic switch installed on each layer of flat layer sensor device, then we can collect the elevator flat layer signal to indicate whether the elevator arrives at the layer;

2) PLC gives five digital output points to correspond to each layer of the selection signal, by giving each layer of the selection button output voltage signal, we can control the elevator reach layers;

3) PLC gives two digital output points to correspond to the opening and closing signal. Through the output voltage signal to open the door and close the door button, we can control the elevator door open and close.

4) PLC gives two digital input points to indicate that the elevator door is in open or closed state by;

5) PLC gives a digital input point which corresponds to the elevator overload switch to indicate whether the elevator is in overload state;

6) PLC gives a digital input point by corresponding signal of the elevator door extension button to indicate whether the elevator is in the state of opening extension, and gives a digital output point corresponding to the elevator door extension button is given to control the elevator door extension by output voltage signal to the door extension button

7) The elevator electrical system reserves four digital quantity input signals and digital quantity output signals for reserve.

In addition, in order to avoid excessive interference of the handling robot in the elevator control system, for the elevator maintenance and emergency repair state:

8) PLC gives a digital input point, corresponding to the installation of a manual maintenance switch in the elevator room. During the maintenance of the elevator, the switch will be in the maintenance position. At this time, the elevator system will not respond to the instructions issued by the RCS, so as to prevent the personnel operation from causing accidents without the knowledge of the RCS in the maintenance process.

9) PLC provides five digital input points to correspond to the newly added emergency stop button in the position of the outgoing call panel on each floor, and a separate signal point allows RCS to judge the position of the signal point.

To sum up, we use the DIGITAL input point of PLC to collect the signal of elevator flat floor, emergency stop, opening state, overload, opening extension and so on, and use the output point to the elevator to output the signal of floor selection, opening, closing and opening
extension to control the elevator operation. The definition of PLC input and output points is shown in Table 2.

| Table 2. Digital input&output point definitions |
|------------------------------------------------|
| I0.0 | I0.1 | I0.2 | I0.3 | I0.4 | I0.5 | I0.6 | I0.7 |
| B1 | F1 | F2 | F3 | F4 | emergency stop of B1 | emergency stop of F1 | emergency stop of F2 |
| I1.0 | I1.1 | I1.2 | I1.3 | I1.4 | I1.5 | I1.6 | I1.7 |
| emergency stop of F3 | emergency stop of F4 | open | close | overload | maintenance | extension | out of service |
| I2.0 | I2.1 | I2.2 | I2.3 | I2.4 | I2.5 | I2.6 | I2.7 |
| Manual | Automatic | Standby 1 | Standby 2 | Standby 3 | Standby 4 | Standby 5 | Standby 6 |
| M0.0 | M0.1 | M0.2 | M0.3 | M0.4 | M0.5 | M0.6 | M0.7 |
| B1 selection | F1 selection | F2 selection | F3 selection | F4 selection | open | close | overload |
| M1.0 | M1.1 | M1.2 | M1.3 | M1.4 | M1.5 | M1.6 | M1.7 |
| Standby 1 | Standby 2 | Standby 3 | Standby 4 | Standby 5 | Standby 6 | Standby 7 | Standby 8 |

2.3. Modbus TCP

Modbus TCP application data unit consists of MBAP header and protocol data unit, and protocol data unit consists of function code and data. Modbus function codes are defined as follows: 0x01 Read coil; 0x02 Read discrete input; 0x03 Read hold register; 0x04 Read input register; 0x05 Write single coil; 0x06 Write a single hold register; 0x0F Write multiple coils; 0x10 Write multiple hold registers[5].

The modbus TCP data packet structure is as follows

Request: 00 00 00 00 06 09 03 00 00 00 01
00 00 is the identifier of the communication transaction;
00 00 indicates the protocol IDENTIFIER. 00 00 indicates modbus.
00 06 is the data length in bytes, which indicates the length of the following data.
09 is the device address, which identifies the address of the remote server connected to the serial line or network. These seven bytes are also called modbus headers;
03 is the function code, and the code 03 is to read the hold register data.
00 00 is the start address of registers.
00 01 is the number of registers.
Response: 00 00 00 00 05 09 03 02 12 34
00 00 is the identifier of the communication transaction. The request of the reply packet is the same as that of the previous request.
00 00 indicates the protocol identifier, which is the same as the previous request.
00 05 is the data length in bytes, which indicates the length of the following data.
09 is the address of the device. The requirement of the reply packet is the same as that of the previous request.
03 is the function code. Normally, the request of the reply packet is the same as that of the previous request.
02 indicates the length of the following data in bytes;
1234 is the data value in the read hold register, that is to say the value in the read hold register addressed 00 00 is 1234h.
2.4. The system process

The interactive business process between the moving robot and the elevator is as follows: Robot move to the elevator door -- Elevator to open the door -- Robot enter the elevator -- Elevator close the door -- Elevator move up and down -- Elevator open the door -- Robot move out of the elevator. (Figure 2)

3. Application results and analysis

The control box receives and stores RCS instructions, then executes them sequentially with the real-time feedback of the execution results. RCS can query the elevator running status and command execution in real time; after the fault has been recovered, the RCS could decide the history instruction whether can be executed continuously.

There is an example in practical application, with a robot in the second floor, now it need to go to the fourth floor, RCS issued to PLC the instruction as follows: 00 00 00 00 00 06 09 03 00 00 00 02, which means check the status of the elevator equipment addressed 09, then PLC replies to RCS with the instruction 00 00 00 00 07 09 03 04 20 10 40 00, indicating that the elevator with the equipment address of 09 is in the second layer, and the state of the elevator now is closed and automatic with no overload, maintenance, extension, or outage. After the robot enters into the elevator, RCS sends out the instruction 00 01 00 00 07 09 10 00 02 04 0F 00 to PLC, indicating that it has been written by signal of 4th layer selection, and then PLC replies to RCS with the instruction 00 01 00 00 00 00 02 00 06 09 10 00 00 00 02, which means that PLC writes data in two registers. When the elevator runs to the 4th floor, the elevator door opens and the robot leaves the car. The task ends.

4. Conclusion

This paper provides a solution for the access and application of moving robot in elevator Internet of things. Compared with the previous elevator Internet of things solutions, the former only knows where the elevator is and what it is doing, but now it can ask the elevator what to do, which increases the interaction. Equipped with this device, do not need to transform the elevator the original electrical wiring, do not need to access the communication protocol of the elevator itself, and it will not affect the running stability of the elevator itself, we can develop software through the way like the RCS of the server system in this article to increase more abundant functions, so as to expand the system application domain.
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