Journal of Applied Data Sciences
Vol. 4, No. 1, January 2023, pp. 15-21

Development of Computer Intelligent Control System Based on Modbus and WEB Technology

Longyi Ran [1,*], Yenchun Jim Wu [2]

[1] Chongqing Chemical Industry Vocational College, China
[2] Graduate Institute of Global Business and Strategy, National Taiwan Normal University, Taipei, Taiwan
ranly@cqcivc.edu.cn *
* corresponding author

(Received: November 18, 2022 Revised: December 8, 2022 Accepted: January 8, 2023, Available online: January 22, 2023)

Abstract

With the increasing popularity of intelligent computer control systems in our country, the accuracy and efficiency of intelligent control systems in the current computer control systems have attracted more and more attention. Modbus and WEB technology have a simple chassis format, compact and powerful functions. Based on the current research status of intelligent computer control technology, this article analyzes the problem of optimizing intelligent computer control systems based on Modbus bus and WEB technology in the application process, and improves the intelligent computer control systems based on Modbus bus and WEB technology.

Keywords: Modbus Bus; WEB Technology; Computer Intelligent Control System;

1. Introduction

Fieldbus technology is a field device interconnection network communication technology that was developed in the early 1990s and applied to the field of process automation and manufacturing automation [1]. It integrates many achievements such as automation control technology, network communication technology, and computer technology. Since 2000, my country has begun to carry out research on the application of industrial fieldbus technology in the field of low-voltage electrical appliances. At present, a pattern of coexistence of multiple buses has been formed [2]. With the continuous improvement of power grid security and power quality requirements, fieldbus technology will be widely used in the field of low-voltage power distribution to realize intelligent power distribution systems and greatly improve the protection level of low-voltage smart components. Especially in recent years, intelligent low-voltage switch appliances (such as intelligent universal circuit breakers, intelligent molded case circuit breakers, intelligent dual power controllers, intelligent motor protectors and starters) have developed rapidly [3]. High-tech products that integrate technology, network technology and information technology with modern mechatronics.

Systems based on the Modbus protocol generally adopt the master-slave mode. There is only one master in the network. The communication is carried out in a query-answer mode. The master sends a message to the slave, and the slave responds to the host's query after receiving the message correctly or according to the master's message. The response action [4]. Moreover, the system communication settings can only be initialized by the host. Communication data transmission in the network is a frame as a unit, and the message is composed of a start bit, device address, function code, data, CRC check, and end character in a corresponding format to form a message frame. In a standard Modbsu network, the system generally can use two communication modes, ASCII and RTU. This system uses RTU (Remote Terminal Unit) communication mode

The intelligent power distribution system based on Modbus protocol integrates various sites to realize centralized monitoring and management, which not only improves the protection level of power distribution, but also improves the efficiency of management [5]. It is simple, economical, and easy to program. At present, the developed distribution automation monitoring system based on Modbus protocol has been in operation in the distribution room of Hangshen Group for more than two years. The electric distribution devices are all domestic products, and the baud

rate is 19.2kbit/s. Manage, monitor and control more than 20 sites including the company's comprehensive building, mold workshop, circuit breaker workshop, assembly workshop, elevator, and contact cabinet. For more than two years, the operation has been stable and reliable, which has played a decisive role in the automation management of the group's power distribution room. The system composition is shown in Figure 1:

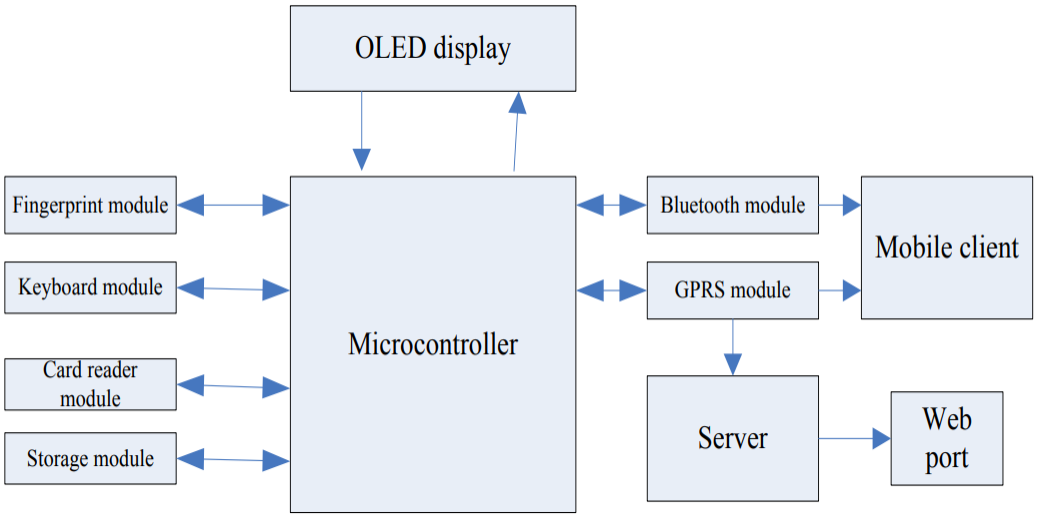

Figure. 1. Computer control system composition

In short, with the development of computer technology, communication technology and control technology, the traditional industrial control field is undergoing an unprecedented change and is beginning to develop in the direction of networking, especially the computer intelligent control system represented by fieldbus. Obtained a broad space for development [5-8].

2. Literature Review

Computer Intelligent Control Systems (CICS) are a type of control system that utilizes computer technology to monitor and control various processes and systems. The development of CICS based on Modbus and WEB technology allows for the integration of various devices and systems through the use of Modbus protocols and the ability to remotely access and control these systems through a WEB interface [9]. The Modbus protocol is an industry standard communication protocol widely used to establish master-slave/client-server communication between intelligent devices. It allows for the integration of various devices and systems such as PLC, DCS, and other industrial devices. The use of WEB technology allows for remote access to the system through a WEB browser, providing convenience and flexibility for the user.

This type of control system can be used in a variety of industries, including manufacturing, building automation, and energy management [10]. In the manufacturing industry, CICS can be used to control and monitor production processes and machinery, allowing for greater efficiency and automation. In building automation, CICS can be used to control and monitor HVAC, lighting, and security systems, leading to energy savings and improved building management. In energy management, CICS can be used to monitor and control power generation and distribution, leading to improved efficiency and cost savings.

The use of Modbus and WEB technology in CICS allows for greater flexibility, scalability, and efficiency in the control of these systems. The Modbus protocol allows for the integration of various devices and systems, while the WEB interface allows for remote access and control of the system [11]. This leads to improved efficiency and convenience for the user, as well as cost savings in the long term. The development of CICS based on Modbus and WEB technology is a step forward in the field of industrial automation, providing a more efficient and flexible way to control and monitor various processes and systems.

Computer Intelligent Control Systems (CICS) based on Modbus technology have been widely studied in recent years in various industrial applications [12]. Research in this field has focused on the use of Modbus protocol in the integration of various devices and systems, as well as the development of control algorithms and strategies to improve the performance and efficiency of these systems.

One area of research has been the use of CICS in the manufacturing industry. Studies have shown that the use of CICS based on Modbus technology can improve production efficiency and automation by integrating and controlling various production processes and machinery [13]. For example, a study by [9] proposed a CICS for a textile manufacturing process, which was able to improve production efficiency and reduce energy consumption by integrating and controlling various production equipment and processes through the use of Modbus protocol.

Another area of research has been the use of CICS in building automation. Studies have shown that the use of CICS based on Modbus technology can improve energy efficiency and building management by integrating and controlling various building systems such as HVAC, lighting, and security. A study by [14] proposed a CICS for a smart building, which was able to improve energy efficiency and building management by integrating and controlling various building systems through the use of Modbus protocol.

In addition to the above, CICS based on Modbus technology are also being used in the field of energy management, specifically in the control and monitoring of power generation and distribution systems. A study by [15] proposed a CICS for a microgrid system, which was able to improve the efficiency and stability of the microgrid by integrating and controlling various power generation and distribution systems through the use of Modbus protocol.

Overall, research has shown that the use of CICS based on Modbus technology can improve efficiency and automation in various industrial applications, including manufacturing, building automation, and energy management. The use of Modbus protocol allows for the integration of various devices and systems, while advanced control algorithms and strategies can further improve the performance and efficiency of these systems.

3. Research Method

3.1. Development environment construction

This system uses KEIL MDK5 as the system development tool, which is the best development tool for the Cortex-M3 core processor. This tool integrates the μVision5 development environment and Real View compiler, has the function of automatically configuring the startup code, and downloads the program through SWD The speed can reach 50M, and the use of Simulation equipment to simulate the environment can speed up the development progress of the product. MDK5 regards MDK Core as an independent installation package, and no longer puts all device support and device drivers in one installation package, but downloads the device support package needed for development through the network [16].

3.2. Modbus bus library functions

As an ARM core chip, STM32F10xx has a large number of registers, and it is more cumbersome to directly configure the registers to implement functions [17]. So ST company developed the STM32 library for this problem. It encapsulates the relevant function registers of STM32 and provides developers with function interface calls. Developers can call these function interfaces to complete the required functions without directly configuring STM32. register. Another advantage of using library functions is that the software code written using library functions is more readable. The comparison between the library development method and the register method development is shown in Figure 2:

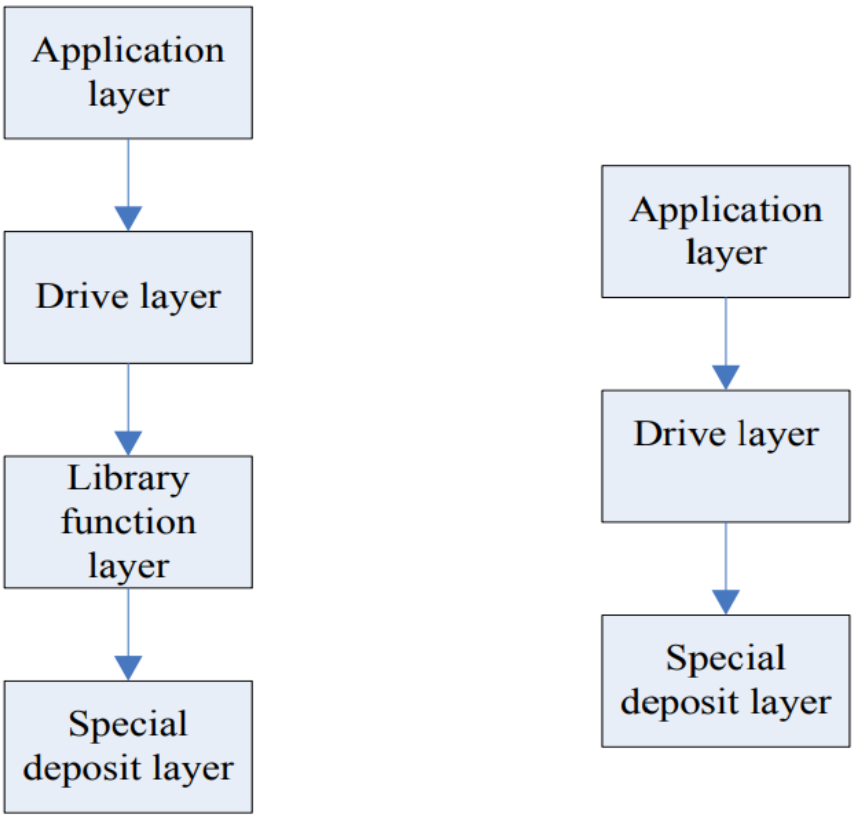

Figure. 2. Comparison of development methods

3.3. Database design

The database used in this system is the relational database MySQL, which focuses on storing user login information and system door opening record information. According to the database design principle, two relational tables are established in the database, namely the user information table and the unlocking record table. User JDBC (Java Database Connectivity) is a Java API that executes SQL statements [17]. It uses the Java language to regulate how the client accesses the application program interface. It can be used in a variety of relational databases and specific operations in the database, the client program does not need to be concerned, this is implemented by the database manufacturer, which acts as an intermediary between the java program and the database [18]. The interaction relationship is shown in Figure 3.

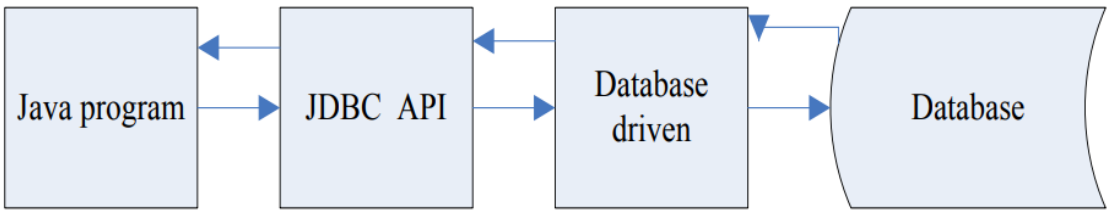

Figure. 3. Interaction

3.4. System real-time

At the same time, an automatic database backup mechanism is added. In addition to manually backing up the historical data of the database every period of time, it is best to add an automatic database backup job to ensure timely stop loss and recovery in the event of a database failure [19]. According to statistical data and expert experience, the weight of the evaluation factors is obtained, and the membership function of each factor is as shown in formula (1) for a group of evaluation factors:

$$T_s = \sum_{i=1}^{n} w_i f_i(i_{si}) \quad (1)$$

Among them, i represents a designated evaluation factor, and s represents a specific set of evaluation factors. After quantization, the input of the BP network is shown in formula (2):

$$I_{si} = \frac{1}{T_s}(w_i f_i(i_{si})) \quad (2)$$

The basic credibility distribution function BPAF formula of the new method adopted in this paper is shown in formula (3):

$$m_i(j) = \frac{B_i(j)}{\Sigma B_i(j)} \quad (3)$$

3.5. System security

First, we must add user authority design to the system [20]. According to system requirements, users are divided into different user roles, and corresponding permissions are given to restrict users' access and operation of key data. When users log in to the system, they must pass the authentication of the username and password. The system will confirm the identity and authority of each user response, open the corresponding interface and page to the qualified users, and prevent unauthorized users from illegally logging in, and control the user's access range. Ensure the safety of the system.

4. Computer intelligent control system design

4.1. Web-side application architecture design

The web application is the most important interactive entry for users in the entire system. In addition to querying real-time and historical capacity data of all production lines, users can also check the working conditions of collection equipment, configure production line information, manage production plans, modify system parameters, and more. Kind of function. The entire web application should have the following functions: It can identify legal user identities. According to actual requirements, users in the system will be divided into 3 levels of authority, and users of different levels have different operating access rights. For ordinary registered users, you can query the real-time and historical capacity data of each production line, production line operation status, production schedule, acquisition equipment hardware status, etc. through the web page; for more advanced office management users, you can request and system For data interaction, the operating authority it has includes the ability to configure production line information, set schedule thresholds and other collection system parameters, add and modify production plans, etc.; for the system administrator, in addition to having all the permissions, he can also manage the entire system All users in the, assign permissions as needed.

4.2. System user and authority design

Modbus/TCP adopts the C/S communication mode, and the server uses port number 502 to communicate with the listening client. This part of the program design mainly includes three parts: establishing a connection, data exchange, and closing the connection. The software design includes the design of the upper computer software and the lower computer software, mainly the lower computer software design. The lower computer communication module mainly completes the initial setting of the Ethernet port communication configuration parameters and the number of modules to receive and send data. The interface parameter initialization is mainly to configure basic parameters such as the format, baud rate, parity bit, and priority of the transmitted data frame. In the process of receiving data from the lower computer, the lower computer is first powered on, the processor initializes the parameters of each interface module, receives the data through the specified interface, and then generates the CRC code, which is compared with the CRC code in the message. If it is not the same, discard it and send error frames. If they are the same, it means that the received message is correct, then parse the message and execute the corresponding command according to the function code. The currently required permissions for this system are shown in Table 1:

Table. 1. System currently required permissions

Operating	Position	Description
Basic query	0×01	Can query basic real-time production capacity; historical production capacity
Plan parameter configuration	0×02	Can modify the system parameters; can view, upload, and modify the production plan
Personnel management	0×04	Ability to add new users; assign and modify user rights
General manager	0×80	Manage the entire web application

5. Conclusion

This article introduces the current situation and development trend of computer intelligent control systems, the application and development of Modbus field bus technology at home and abroad. This article introduces the design of computer intelligent control systems. The content is the overall design of the system, including structure, cabinet design, Modbus field bus software and hardware design, configuration interface design and database design. This article introduces the realization and application analysis of computer intelligent control systems. The content is Modbus field bus realization system.

In conclusion, the development of Computer Intelligent Control Systems (CICS) based on Modbus and WEB technology is a significant advancement in the field of industrial automation. The use of Modbus protocol allows for the integration of various devices and systems, while the WEB interface allows for remote access and control of the system, providing convenience and flexibility for the user. This type of control system can be used in a variety of industries, including manufacturing, building automation, and energy management, and can lead to improved efficiency and automation. Research has shown that CICS based on Modbus technology can improve production efficiency, energy efficiency and building management, stability of power generation and distribution systems. However, it is also important to note that the implementation of such systems may require a certain level of technical expertise and resources. Therefore, it is important to carefully evaluate the benefits and costs before implementing a CICS based on Modbus and WEB technology.

References

[1] H. Mo and G. Farid, “Nonlinear and adaptive intelligent control techniques for quadrotor uav–a survey,” Asian J. Control, vol. 21, no. 2, pp. 989–1008, 2019.

[2] F. Farivar, M. S. Haghighi, A. Jolfaei, and M. Alazab, “Artificial intelligence for detection, estimation, and compensation of malicious attacks in nonlinear cyber-physical systems and industrial IoT,” IEEE Trans. Ind. informatics, vol. 16, no. 4, pp. 2716–2725, 2019.

[3] D. Bhamare, M. Zolanvari, A. Erbad, R. Jain, K. Khan, and N. Meskin, “Cybersecurity for industrial control systems: A survey,” Comput. Secur., vol. 89, p. 101677, 2020.

[4] F. Zhu, Y. Lv, Y. Chen, X. Wang, G. Xiong, and F.-Y. Wang, “Parallel transportation systems: Toward IoT-enabled smart urban traffic control and management,” IEEE Trans. Intell. Transp. Syst., vol. 21, no. 10, pp. 4063–4071, 2019.

[5] B. Wang, S. J. Hu, L. Sun, and T. Freiheit, "Intelligent welding system technologies: State-of-the-art review and perspectives," J. Manuf. Syst., vol. 56, pp. 373–391, 2020.

[6] R. P. Borase, D. K. Maghade, S. Y. Sondkar, and S. N. Pawar, "A review of PID control, tuning methods and applications," Int. J. Dyn. Control, vol. 9, pp. 818–827, 2021.

[7] F. Rossi, J. P. Sembiring, A. Jayadi, N. U. Putri, and P. Nugroho, "Implementation of Fuzzy Logic in PLC for Three-Story Elevator Control System," in 2021 International Conference on Computer Science, Information Technology, and Electrical Engineering (ICOMITEE), 2021, pp. 179–185.

[8] Z. Lv and L. Qiao, "Deep belief network and linear perceptron based cognitive computing for collaborative robots," Appl. Soft Comput., vol. 92, p. 106300, 2020.

[9] W. Koch, R. Mancuso, R. West, and A. Bestavros, "Reinforcement learning for UAV attitude control," ACM Trans. Cyber-Physical Syst., vol. 3, no. 2, pp. 1–21, 2019.

[10] J. Miranda, P. Ponce, A. Molina, and P. Wright, "Sensing, smart and sustainable technologies for Agri-Food 4.0," Comput. Ind., vol. 108, pp. 21–36, 2019.

[11] S. Zhao, F. Blaabjerg, and H. Wang, "An overview of artificial intelligence applications for power electronics," IEEE Trans. Power Electron., vol. 36, no. 4, pp. 4633–4658, 2020.

[12] J. Jayakumar, B. Nagaraj, S. Chacko, and P. Ajay, "Conceptual implementation of artificial intelligent based E-mobility controller in smart city environment," Wirel. Commun. Mob. Comput., vol. 2021, pp. 1–8, 2021.

[13] H. Liang, J. Zou, K. Zuo, and M. J. Khan, "An improved genetic algorithm optimization fuzzy controller applied to the wellhead back pressure control system," Mech. Syst. Signal Process., vol. 142, p. 106708, 2020.

[14] Z. Lv, Y. Han, A. K. Singh, G. Manogaran, and H. Lv, "Trustworthiness in industrial IoT systems based on artificial intelligence," IEEE Trans. Ind. Informatics, vol. 17, no. 2, pp. 1496–1504, 2020.

[15] Z. Ning et al., "Joint computing and caching in 5G-envisioned Internet of vehicles: A deep reinforcement learning-based traffic control system," IEEE Trans. Intell. Transp. Syst., vol. 22, no. 8, pp. 5201–5212, 2020.

[16] J. Qi, G. Jiang, G. Li, Y. Sun, and B. Tao, "Intelligent human-computer interaction based on surface EMG gesture recognition," Ieee Access, vol. 7, pp. 61378–61387, 2019.

[17] M. Mao, L. Cui, Q. Zhang, K. Guo, L. Zhou, and H. Huang, "Classification and summarization of solar photovoltaic MPPT techniques: A review based on traditional and intelligent control strategies," Energy Reports, vol. 6, pp. 1312–1327, 2020.

[18] H. Yang, A. Alphones, Z. Xiong, D. Niyato, J. Zhao, and K. Wu, "Artificial-intelligence-enabled intelligent 6G networks," IEEE Netw., vol. 34, no. 6, pp. 272–280, 2020.

[19] R. Y. Zhong, X. Xu, E. Klotz, and S. T. Newman, "Intelligent manufacturing in the context of industry 4.0: a review," Engineering, vol. 3, no. 5, pp. 616–630, 2017.

[20] J. Pan, R. Jain, S. Paul, T. Vu, A. Saifullah, and M. Sha, "An internet of things framework for smart energy in buildings: designs, prototype, and experiments," IEEE internet things J., vol. 2, no. 6, pp. 527–537, 2015.