Design of Cloud Control System for Supply-oils of color Offset Press

Xiaopeng Zhou, Peng Cao, Mingfei Wang

Abstract: Traditional control method of printing-oils for color offset press is usually based on a single computer system, which has many inconveniences in realizing remote control and centralized management. We designed a CMYK oil-supply control system based on cloud, edge and end-devices. The system is divided into clouds layers, the edge layer and the field equipment layer. The computer is used as the server of the cloud layer and the edge node of the edge layer, design a visual interface through LabVIEW software. STM32 is used as the core controller of the master station and the slave station of the field equipment layer. The STM32 of the master station is transplanted with μC/OS-Ⅲ operating system and LwIP protocol Stack. The master station is connected with the slave station by RS485 bus, and it is connected with the edge node by Ethernet, which realized multi-task scheduling and completed the protocol conversion. Experiments show that system has reduced the delay of transmission by 80% compared to the traditional technology, and the control precision of supply-oil-keys have increased some, at the same time, it also has better performance in real-time and reliability.

Index Terms: color offset press, printing-oils, control system, cloud-edge-end computing

1 INTRODUCTION

AT present, the cloud computing is generally adopted in the industrial field. However, in the face of the explosive growth of data, cloud computing also shows some drawbacks: data security and privacy is not protected [1], the real-time nature of data transmission Low [2], network bandwidth limitations, and high energy consumption. If edge computing is introduced into the system [3], [4], [5], [6], cloud computing and edge computing can cooperate with each other to achieve cloud-side collaboration, task scheduling, and unified resource management [7], these the problems will be solved. Companies such as Yingongsha, Hucai Printing and Yunchuang Technology have also closely integrated printing with the Industrial Internet[8], providing printing companies with low-cost solutions for printing standardization, digitization, informatization, and intelligence. On the basis of the above research, this paper proposes cloud control system for Supply-oils of color offset press, which based on cloud, edge and end-devices. By improving the system's real-time performance and supply-oil-keys control accuracy, it aims at improve printing quality, reduce failure rates and save printing costs.

- *Xiaopeng Zhou is currently pursuing masters degree program in Beijing Institute of Graphic Communication, China, PH-13551446934. E-mail: xpzhou2021@163.com*
- *Peng Cao is the director of Beijing Key Laboratory of Signal and Information Processing for High-end Printing Equipment in Beijing Institute of Graphic Communication, China, PH-13311010311. E-mail: pcaorf2012@163.com*

2 SYSTEM OVERALL DESIGN

2.1 Systems solutions design

Cloud control system for Supply-oils is composed of cloud layer, the edge layer and field equipment layer. In terms of task distribution, the cloud layer is responsible for managing all edge nodes, while the edge nodes hand over the difficult computing and storage tasks to the cloud layer to complete, the cloud server sends training models to edge nodes through wireless communication, such as CNN fault diagnosis model and the color model, the edge node uploads the data, which collected by the device, to the database of cloud server. The edge layer is composed of two parts: an edge node and an edge manager. The edge node is a hardware entity, and the edge manager is a software entity. Computing tasks are executed on the edge node, at the same time, the edge manager manages the edge nodes. we selects a processor inter i5-8500 with a main frequency of 3 GHz and a computer with 8 GB of memory as the edge node. The edge layer is connected to the master station of the field device layer through the industrial Ethernet and completes data interaction, and the edge layer also completes the task collaboration with the cloud layer. The field equipment layer is composed of a master station, a slave station and an offset press. The slave station and the edge node carry out data forwarding and protocol conversion, and the master station plays a vital role. At the same time, the master station performs some real-time tasks, such as fault detection. The cloud control system architecture is shown in Figure 1.

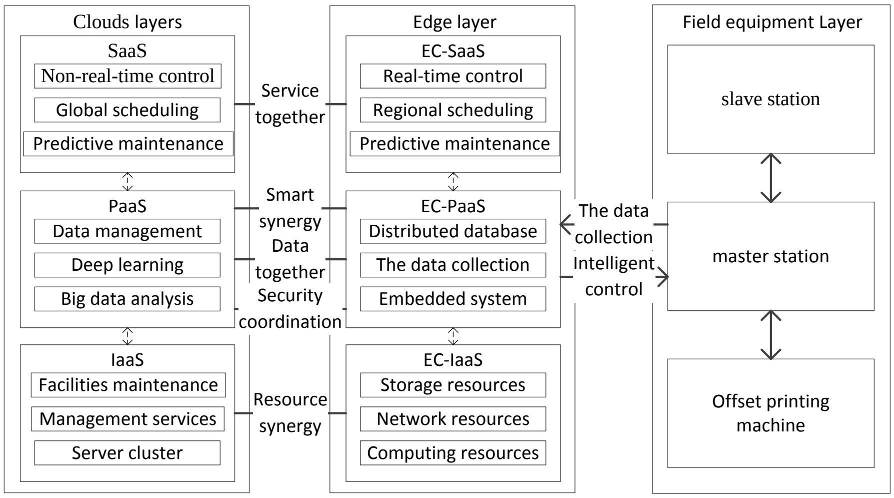

Fig. 1. Cloud control system architecture

2.2 Edge security

The white paper on edge computing security shows that edge security is an important guarantee for edge computing. Edge security includes the entire security protection system from edge computing to cloud computing.Edge computing brings many advantages and difficulties, so the following countermeasures are proposed.he white paper on edge computing security shows that edge security is an important guarantee for edge computing. Edge security includes the entire security protection system from edge computing to cloud computing. There are many dangerous communication protocols between terminal equipment and edge nodes, lack of data encryption mechanism and security authentication measures. However, symmetric cryptosystem can reduce the complexity of computing tasks during the authentication process. With fewer computing tasks and storage resources, completing the secure communication between the device and the edge node. Compared with cloud servers, edge nodes are still at a disadvantage in terms of information filtering, data backup, data recovery, and security detection. After the edge node is attacked by a single point, the data can be easily destroyed and tampered by criminals, causing a lot of economic losses and information leakage. Therefore, privacy protection mechanisms can be set at the edge layer to avoid these problems. Because the data at the edge layer has the characteristics of multiple types and fast updates, multiple privacy algorithms can be optimally combined to achieve the effect of protecting heterogeneous data, such as differences Privacy, K-anonymity algorithm and privacy protection data aggregation. It is easy for edge nodes to download computing tasks and resources from a third-party supply chain from the cloud server, or insecure API interfaces are called during the download process, resulting in potential security risks for edge nodes. Intrusion detection systems can be deployed at the edge layer, and machine learning algorithms and predictive models can be used to obtain better intrusion detection results to adapt to changing attack patterns. For example, some algorithms such as decision tree and logistic regression can be used to judge whether the edge node has been invaded. The physical isolation at the edge layer is relatively mature, and the protection mechanism using software is not yet complete. Hackers and attackers can deploy devices such as pseudo base stations and gateways at the edge layer. Once users connect, their data and privacy will be leaked. An analysis model can be established to strengthen software protection, such as the hesitant fuzzy language envelope analysis model based on the analytic hierarchy process, which can well integrate network information security, effectively evaluate network edge security, and avoid user data leakage Intensify.

2.3 Hardware design of field equipment layer

The field equipment layer has a master and multiple slaves. The master tation uses STM32F407ZGT6 as the control core, and the slave station uses STM32F103C8T6 as the control core. In Ethernet communication, STM32F407 of master station has the IEEE 802.3 standard media access control layer (MAC), connect the physical layer (PHY) LAN8720A chip through the SPI interface [9], which can transmit 10/100 Mb/s full duplex data. The wireless communication module uses the ESP8266 chip [10], and burns the Gizwits firmware [11]. SP3485 chip is used to transmit data between master station and slave station [12], at the same time, it is a hardware entity that implements the Modbus-RTU protocol, which uses a half-duplex data transmission method. When the master station is connected to a large number of slave stations, the matching resistance and bias resistance should be appropriately increased to ensure stability. EN25Q128 chip as external memory to save lightweight data, such as supply-oils of color Offset Press. The hardware structure of the field equipment layer is shown in Figure 2.

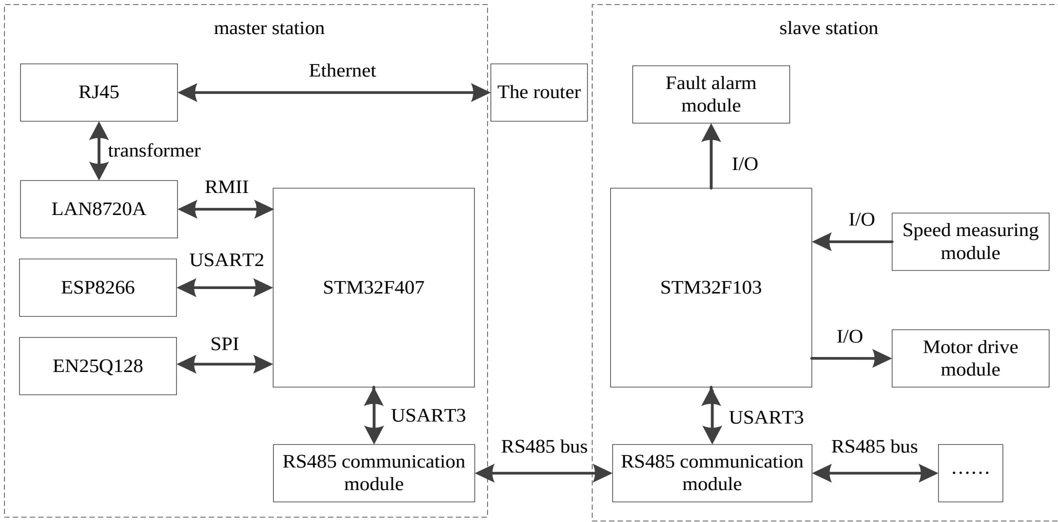

Fig. 2. Hardware structure of field equipment layer

3 System software design

3.1 Modbus protocol

Modbus protocol is widely used in data transmission in the field of industrial control. The protocol adopts the method of message transmission, mainly including ASCII, RTU and TCP three message types [13], [14]. ASCII is larger than RTU in the amount of data transmission, but the data transmission efficiency is lower. Therefore, we adopts Modbus-RTU protocol for serial link communication, and use 485 bus as the transmission medium. We use writing multiple coils, reading coil status, and reading input registers. The master station uses the Modbus-TCP protocol to communicate with the edge nodes on the network link, and Ethernet is used as the transmission medium. The Modbus-RTU protocol message frame is composed of slave address, function code, data field and CRC check. During data transmission, a maximum of 255 slave stations can be connected to 1 master station, which meets the system's requirements for the number of slave stations. Then, compared with the Modbus-RTU protocol, the Modbus-TCP protocol adds the MBAP header and removes the CRC check code. The accuracy and response delay of Modbus-RTU and Modbus-TCP protocols can be verified through Modbus Slave and Modbus Poll tools.

3.2 task scheduling

µC/OS-III [15] is an open source real-time operating system, which can realize parallel processing of multiple tasks through task scheduling and switching, ensuring the real-time requirements of the system. We set the priority according to the importance of the task, A smaller number indicates a higher priority, some of the priorities are occupied by internal tasks in the system, which cannot be used. High-priority tasks are executed first, but priority inversion, the problem can be solved by adding mutually exclusive semaphores. At the same time, some high-complexity and long-period tasks are added to critical zone protection, and the tasks can have sufficient time to execute through time slice round-robin scheduling. We use SystemView[16] tool to intuitively obtain task processing time and priority. The task scheduling of the master station is shown in Table 1. The task of position of supply-oil-keys initialization and adjustment will be automatically suspended during fault processing, and will not be restored until the fault processing is completed. At this time, the entire visualization interface is in a read-only state to avoid complicating the fault due to accidental touch. The tasks 2 and 6 use the same a semaphore. When the system is in the starting state, only task 2 can request the semaphore, and send commands to five slave stations in a cycle of 200 millisecond, when the system is in idle state, only Task 6 can request the semaphore and send commands to five slave stations in a cycle of 1 second. Because the system rarely fails in the idle state, the priority is set to the lowest, and the cycle of collecting data will longer. Data reporting is to report the fault type and system operating status, including transmission delay and position of supply-oil-keys.

TABLE 1 Task scheduling of the master station

number	priority	name	capacity/B
1	3	Fault handling	128
2	4	Data is collected at startup	128
3	5	The position of supply-oil-keys initialization	128
4	6	The position of supply-oil-keys adjustment	128
5	7	The data reported	512
6	8	Data is collected at leisure	128

3.3 Visual interface

The Supply-oils control system is designed based on cloud, edge and end-devices. The application control interface is shown in Figure 3. The Application is developed by Android Studio and adopts MVC architecture. The ESP8266 Wi-Fi module of the master station uses the smartConfig mode to connect to the designated SSID route to complete the network configuration, and sends the data to the Gizwits cloud platform through the MQTT protocol, following the browser/server model. We stores the Wi-Fi information and parameter settings by method of SharePreference, and the data collected by the device can be saved in the local and server SQLite databases.

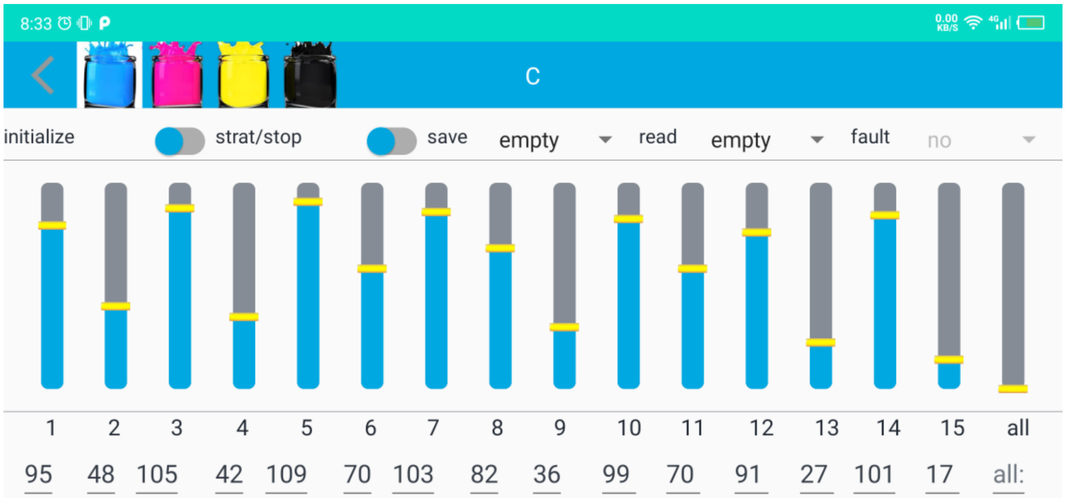

Fig. 3. Application control interface

The voltage acquisition interface of the web server is shown in Figure 4. The web server is realized at the master station through the RAW API programming interface provided by LwIP, and the web server is accessed through a web browser in the local area network to achieve the purpose of remotely monitoring the master station. The entire web page interface is made by Dreamweaver software. The main website and web page data interaction operations are completed through Common Gateway Interface (CGI) technology. If there are n variables, 2n web pages need to be made, through Service Side Include, SSI) technology loads the information collected by the master station through the slave station to the corresponding position of the web page. In order to display this information in real time, the web page refresh time is set to 0 ms.

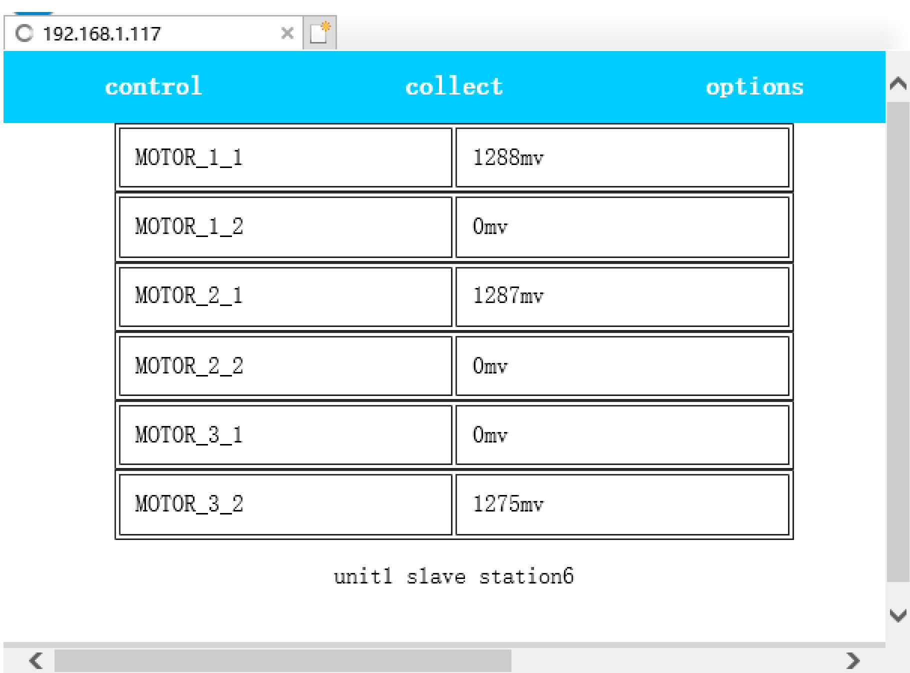

Fig. 4. Voltage acquisition interface of the web server

The front panel of LabVIEW program is shown in Figure 5. After the master station and the router was connected through the Ethernet, the IP address is automatically assigned through DHCP, and the LwIP protocol stack is used to implement TCP/IP communication with LabVIEW. We use the LabVIEW Modbus library to create and write multiple coils, read input registers, and write multiple register sub vi, write LabVIEW front and back panel programs, and at the same time, we save and read parameters through external memory, and the data collected by the device can be saved In the Access database.

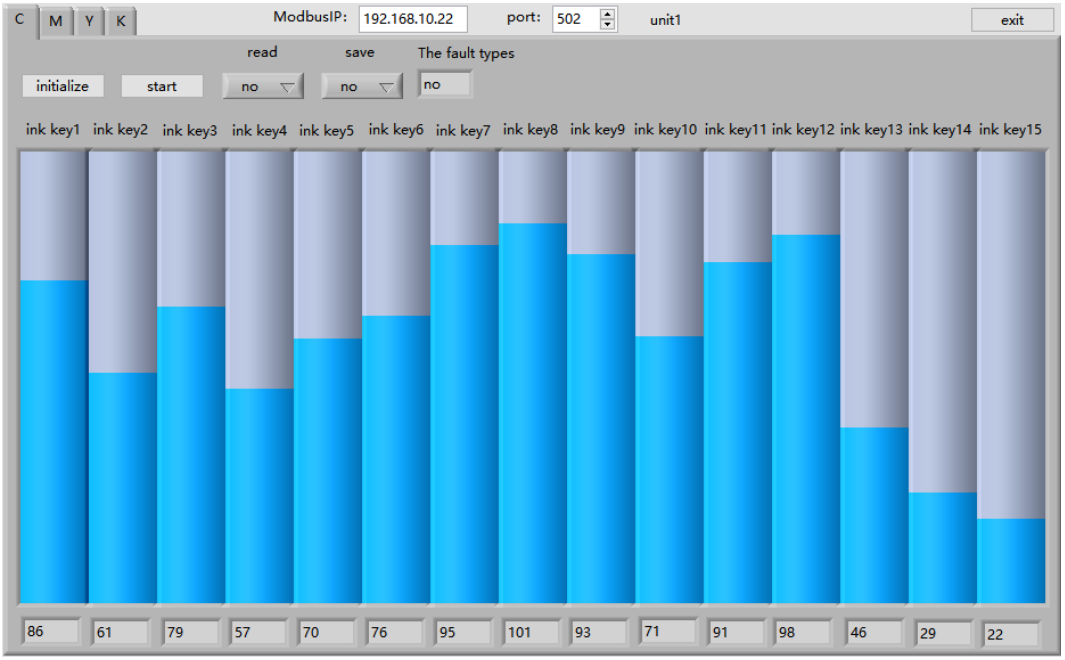

Fig. 5. Front panel of the LabVIEW program

4 EXPERIMENTAL TESTING AND ANALYSIS

4.1 Comparative experiment design

Scheme 1: The master station of Field equipment Layer is connected to a public server through the Internet, and the conversion between Modbus-RTU and MQTT protocols is completed in the master station. Scheme 2: The master station implements a web server through the RAW API programming interface provided by LwIP, and we control the master station and observe the collected data through a web browser in the same local area network. Scheme 3: The master station of Field equipment Layer is connected to the edge node through a local area network, and the conversion between Modbus-RTU and Modbus-TCP protocols is completed in the master station. The master station of the three schemes is connected with the slave station through the RS485 bus, and adopt Modbus-RTU protocol for data transmission.

4.2 Analysis of experimental results

Perform statistical calculations on 300 data sets according to the three schemes designed for comparative experiments. The accuracy of supply-oils and data transmission delay are shown in Figure 6 and Figure 7. Schemes 1 to 3 data transmission delays were 1100 millisecond, 238 millisecond, and 225 millisecond respectively, and accuracy of supply-oils was respectively 98.4%, 99.1% and 99.4%. From the comparison of scheme 1 and scheme 2, it can be seen that scheme 2 makes the system have the characteristics of high precision and low delay. However, scheme 2 requires the production of a large number of web pages, and the data cannot be effectively saved and corrected. Embedded performance requirements are high and insufficient. Therefore, on the basis of option 1, private servers can be rented to replace public servers, but this will increase the cost of the design. Scheme 3 is very close to scheme 2 in terms of transmission delay and accuracy of supply-oils. In addition, the data can be processed and stored at the edge node, and then transmitted to the server for more complex calculations. At the same time, the TCP/IP used in scheme 3 Protocol communication provides a more reliable data transmission mechanism, so scheme 3 is more in line with the needs of the industrial control field.

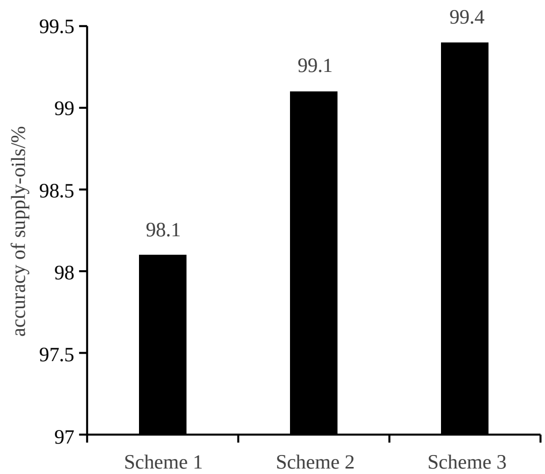

Fig. 6. Accuracy of supply-oils

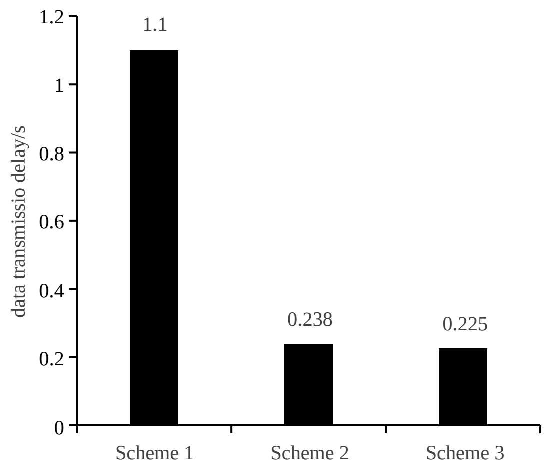

Fig. 7. Data transmission delay

5 Conclusion

This paper proposes cloud control system for Supply-oils of color offset press based on cloud, edge and end-devices. The system includes clouds layers, edge layer and field equipment layer. We complete hardware deployment, task scheduling, and gateway design, which provides an idea for the unified utilization of heterogeneous resources in edge measurement. It is verified by experiments that the scheme proposed in this paper can achieve high-precision and low-latency control of supply-oil-keys, low cost, good scalability, and has fault detection and processing capabilities. But for the cross-platform migration execution of computing tasks, knowledge sharing between devices, and global scheduling, this article is still in the preliminary research stage. Later, we can conduct in depth research on cloud-side collaborative and model training.

Acknowledgment

Thanks to Beijing Fund-Municipal Education Commission Joint Project(KZ202010015023) and Research Project of Beijing Institute of Graphic Communication(Ef202001).

References

[1] J. Zhang, Y. Zhao and B. Chen, “A Review of Edge Computing Data Security and Privacy Protection,” Journal of Communications, vol. 39, no. 3, pp. 1-21, 2018.

[2] Q. Wang, G. Jin, Q. Li, K. Wang, Z. Yang and H. Wang, “Research Status and Prospect of Industrial Edge Computing,” Information and Control,vol. 50, no. 3, pp. 257-274, 2021.

[3] Y. Chen, J. Hu, “Industrial application based on edge computing: automatic guided vehicle control system,” Computer Integrated Manufacturing Systems, vol. 25, no. 12, pp. 3191-3198, 2019.

[4] C. Peng, X. Tang and J. Lu, “Bearing fault diagnosis based on edge computing,” Modular Machine Tool & Automatic Manufacturing Technique, pp. 52-55, Dec 2020.

[5] J. Qian, B. Duan, W. Xie and Y. Zhao, "Edge Computing for Brightness and Color Temperature of Smart Streetlight," 2021 IEEE 2nd International Conference on Big Data, Artificial Intelligence and Internet of Things Engineering (ICBAIE), pp. 699-703, 2021.

[6] R. Wang, Y. Liu, P. Zhang, X. Kang and X. Li, “A collaborative entity search method based on edge cloud for Internet of Things,” Computer Engineering, vol. 46, no. 8, pp. 43-49, 2020.

[7] P. K. Sharma, S. Rathore, Y. Jeong and J. H. Park, "SoftEdgeNet: SDN Based Energy-Efficient Distributed Network Architecture for Edge Computing," in IEEE Communications Magazine, vol. 56, no. 12, pp. 104-111, Dec 2018, doi: 10.1109/MCOM.2018.1700822.

[8] X. Wan , Z. Jiao, M. Liu and D. Liu, “A review of industrial Internet applications,” J. Digital Printing, vol. 4, no. 2, pp. 1-26, 2021.

[9] Z. Chen , J. Yang, “Design and Implementation of Embedded Device Web Server Based on LwIP,” J. Electronic Design Engineering, vol. 26, no. 11, pp. 110-113, 2018.

[10] L. Qin, T. Wang and X. Hu, “Design of Remote Control Electromagnetic Lock for Mobile Phone Based on ARM9 and WIFI,” J. Electronic Design Engineering, vol. 28, no. 12, pp. 153-156, 2020.

[11] Q. Zhang, P. Gao and X. Li, “An intelligent water quality detector design,” Foreign Electronic Measurement Technology, vol. 40, no. 2, pp. 112-115, 2021.

[12] Y. Qin, W. Li and P. Fang, “Design of laboratory air Monitoring and purification System based on STM32,” J. Electronic Design Engineering, vol. 27, no. 24, pp. 94-98, 2019.

[13] URREA C, MORALES C, KERN J, “Implementation of error detection and correction in the Modbus-RTU serial protocol,” International Journal of Critical InfrastructureProtection, pp. 27-37, Dec 2016.

[14] TITAEV A, “Reducing update data time for exchange via MODBUS TCP protocol by controlling a frame length,” Automatic Control and Computer Sciences, vol. 51, no. 5, pp. 356-365, 2017.

[15] Z. Wang, X. Zhou and H. Lin, “Design of Universal Real-time Thermocouple Temperature Measuring Sequence for Rotation Scheduling,” Instrument Technique and Sensor, pp. 23-27, Sep 2019.

[16] L. Li, H. Jin, X. Sun and L. Li, “Design of Intelligent Building Gateway Based on Edge Computing and Priority Classification,” J. Modern Electronics Technique, vol. 44, no. 6, pp. 67-71, 2021.