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# Research and Development of Ethernet Communication System in Numerical Control Workshop

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***Abstract***

*There are 10 sets of CNC equipment in a numerical controlled workshop, and set up the CAD/CAPP/CAM center, there is a problem that each production unit is an information island, which can not implement informatization management. This paper takes ZNE-100TL module realized the embedded Ethernet and RS-232C data transfer function as the hardware platform, takes VC++ as software platform, applied Ethernet technology to realize communication the CNC equipment with CAD/CAPP/CAM center. This is good for production management and data transmission in numerical controlled workshop, which can improve the production efficiency.*

***Keywords:*** *Numerical controlled workshop; Ethernet; Communication System*

## 1. Introduction

As the development of the control, computer, communication and network technology, information communication is rapidly covering the field equipment layer, control and management of all levels in the factory [1-2]. At present, the Ethernet and TCP/IP protocol has become the DE facto standard in the world, the Ethernet based on TCP/IP protocol can meet the needs of industrial monitoring system at all levels [3-4]. Compared with the previous industrial monitoring network, industrial monitoring network based on Ethernet has incomparable advantages, Ethernet has a higher communication bandwidth, which can meet the needs of the growing data communication, Through TCP/IP protocol, Ethernet can easily achieve remote monitoring and management of the field device. Ethernet device is cheap, simple implementation, can largely reduce the cost of monitoring and control system [5-6].

This paper realized the communication function of Numerical controlled workshop through the Ethernet technology, solved informatization problems of the numerical control equipment in the process of production.

## 2. Hardware Design

Modern CNC system communication widely adopt the master-slave mode [7], that is the structure of the upper computer and lower computer [8-9], which allows users to the second independent research and development and upgrade, which has openness of the computer and

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the control end. This paper uses the Ethernet communication between upper machine and lower machine, standard and open is the advantages of Ethernet communication.

### 2.1. Overall Design

NC workshop is composed of 10 the numerical control equipments, which is shown in Table 1. NC workshop set up the CAD/CAPP/CAM center, which can not directly connect with numerical control equipments and give full play to the advantages of NC equipment. Therefore, NC workshop will connect all of the CNC equipments with Ethernet, realize the informationization management, data transfer, enhances the capability communication, strengthen the management of information integration.

**Table 1. NC Equipment Data**

| serial number | Device name | Device model | Device quantity | Communication interface | Purchasing period |
|---|---|---|---|---|---|
| 1 | CNC machining center | OMD | 2 | RS-232C | 2006 |
| 2 | CNC grinding machine | VFI | 2 | RS-232C | 2006 |
| 3 | CNC lathe | HAAS | 2 | RS-232C | 2007 |
| 4 | CNC machining center | HAAS | 2 | RS-232C | 2006 |
| 5 | CNC milling machine | HERMLE | 2 | RS-232C | 2006 |

Because Windows operating system has some advantages of rich development resources and easy operating, the upper computer (HMI) of numerical control workshop adopts microcomputer installed WinXP microcomputer operating system, the lower computer (NCU) adopts the module of ZNE-100TL (Guangzhou Zhiyuan electronics co., LTD), which can realize the embedded Ethernet and RS-232C data conversion. Hardware system overall design is shown in Figure 1.

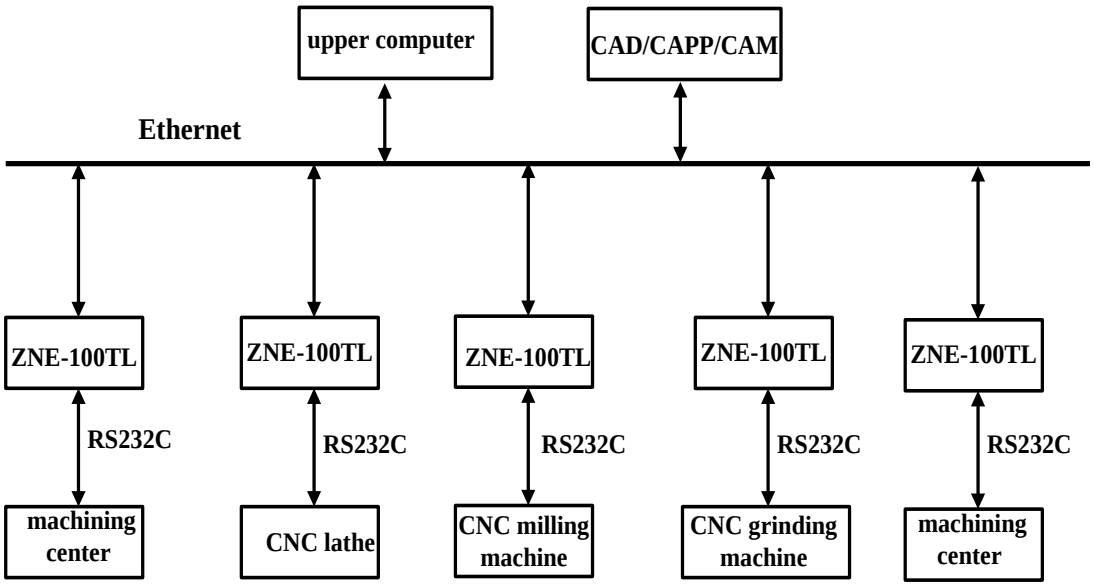


**Figure 1. Hardware System Overall Design**

### 2.2. Ethernet and RS-232C Data Conversion Module

ZNE-100TL is a more functional data transfer module completed the embedded Ethernet and RS-232C [10], hardware connection of ZNE-100TL and RS232C is shown in Figure 2. ZNE-100TL internal integration of the TCP/IP protocol stack, the user can use it to easily complete the networking of the embedded devices, save manpower, material resources and development time.

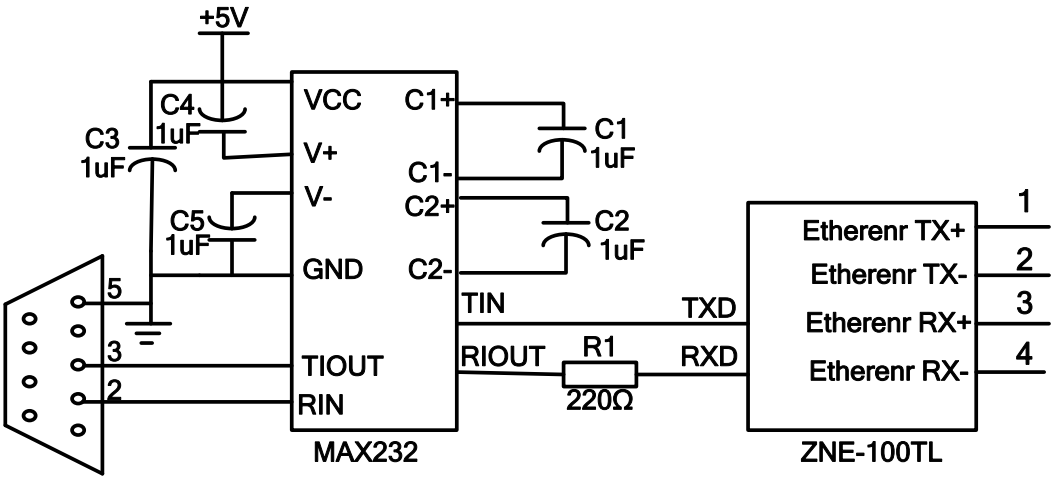


**Figure 2. Hardware Connection of ZNE-100TL and RS232C**

ZNE-100TL internal integration 10/100 M adaptive Ethernet interface, high baud rate of serial communication is 230.4 Kbps, ZNE-100TL has the many kinds of working mode such as TCP Server, the TCP Client, UDP and Real COM driver, which is compatible with the SOCKET works.

ZNE-100TL must be properly configured before it works normally, obtaining IP way is set to dynamical mode in ZNE - 100TL configuration software, working mode of ZNE - 100 TL is TCP Server, which is always waiting for the client connection in this mode, it can be a two-way data communications after establishing a TCP connection with the client.

## 3. Software Design

PC communication software conform to standard rules of the SOCKET，communications systems use WINSOCK control programming in VC++ platform [11-12].

### 3.1. Operation Interface Design

Operation interface of upper computer is shown in Figure 3, the first half of the interface is information exchange of the upper computer with CAD/CAPP/CAM center, which include upload and download of parts processing process, query and feedback of parts processing process, query service and feedback of parts design drawings, etc. the lower part of the interface is information exchange of the upper computer with the numerical control equipment, which include number query of CNC equipment, production task arrangement of CNC equipment, equipment failure and maintenance of CNC equipment, upload and download of parts processing process, *etc.*

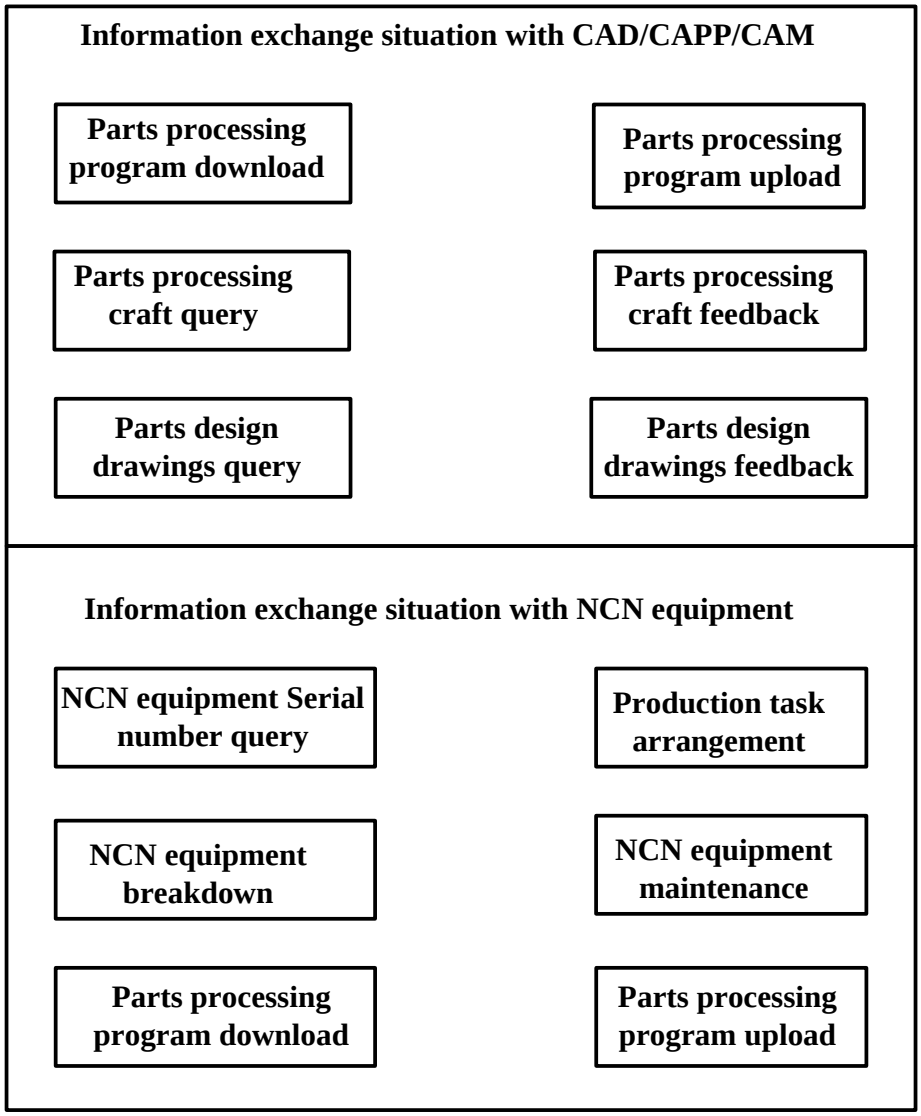


**Figure 3. Operation Interface of the Upper Computer**

### 3.2. Program Flow

Through the Ethernet communication, at least need a pair of sockets, one runs on the upper computer, which called ClientSocket, another runs on ZNE-100TL, which called ServerSocket. According to the way of starting connection and the target connecting local socket, socket connection process can be divided into three steps, which are server monitoring, the client request and connection confirmation, respectively.

The socket is divided into three categories, streaming socket based on TCP connections provide no record boundary data flow among them, send and receive at the same time through the socket, which has no data error, no repeat sent, and receive in sending order. When the connection of the upper computer and ZNE_100TL module is established, the process of receiving and sending data process is shown in Figure 4.

 

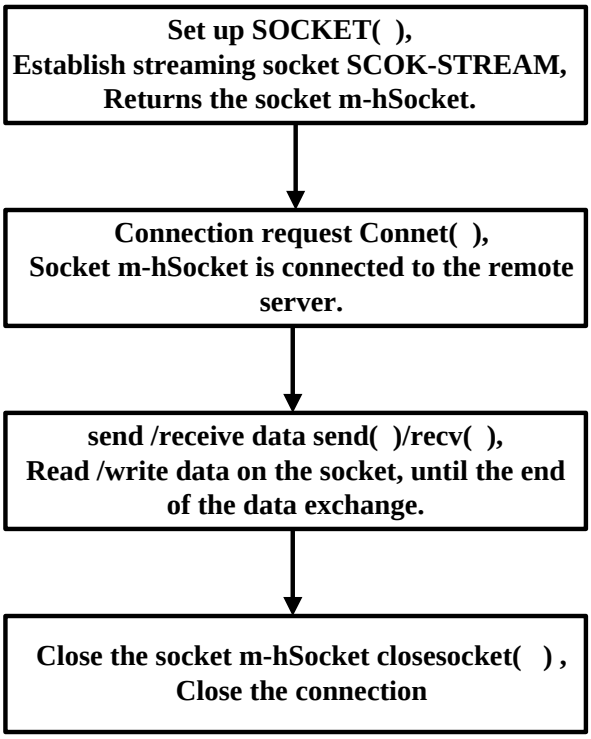


**Figure 4. Data Flow Diagram of Sending and Receiving**

## 4. Communications Function

### 4.1. Alarm Function

The alarm information of numerical control system is very important for the maintenance and the safety in machining process, so Operation interface of upper computer must show alarm information of the numerical control system.

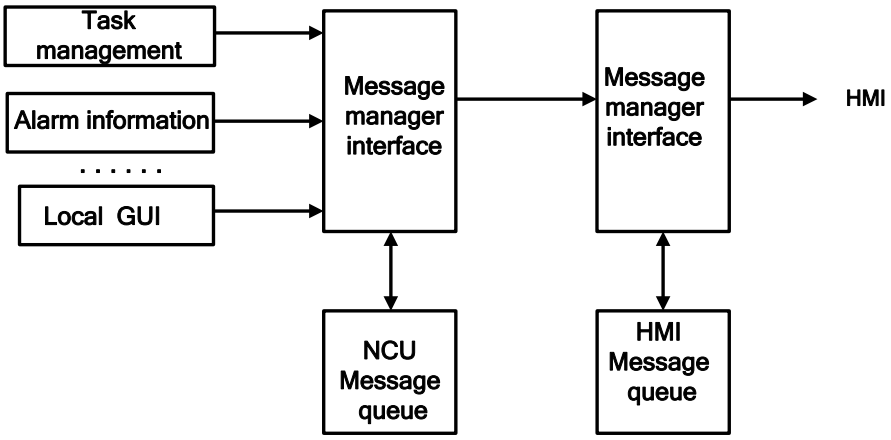


**Figure 5. The Process of Alarm Service**

Alarm service will transmit alarm information of the numerical control system (NCU) to the upper computer (HMI). Numerical control system and the upper computer adopts unified message manager, in the alarm server monitoring message queue of numerical control system, if there is a new message, the new alarm information will be sent to the operation interface of the upper computer through the alarm service port. The upper computer monitor alarm service port, which will call the message management interface if there is new alarm information, and added to the interface message queue of the operation interface of the upper computer. The process of alarm service is shown in Figure 5.

### 4.1. Data Transmission Function

The file of NC machining program and the process parameters often need to be transported between upper and lower computer, so the file transfer service is necessary, which mainly provide the directory and the file upload and download, etc. In the file download service status, the upper computer sent file header, file body and the end of file identification, the lower computer receives the file and store it. In the file upload service status, the lower computer sent file header, file body and the end of file identification, the upper computer receives the file and store it. In a directory service state, the directory is transformed into the transmission file. In the file transmission process, if overtime or the operation code appeared not match with the state, communication system will be reset. The state of the file transmission server is shown in Figure 6.

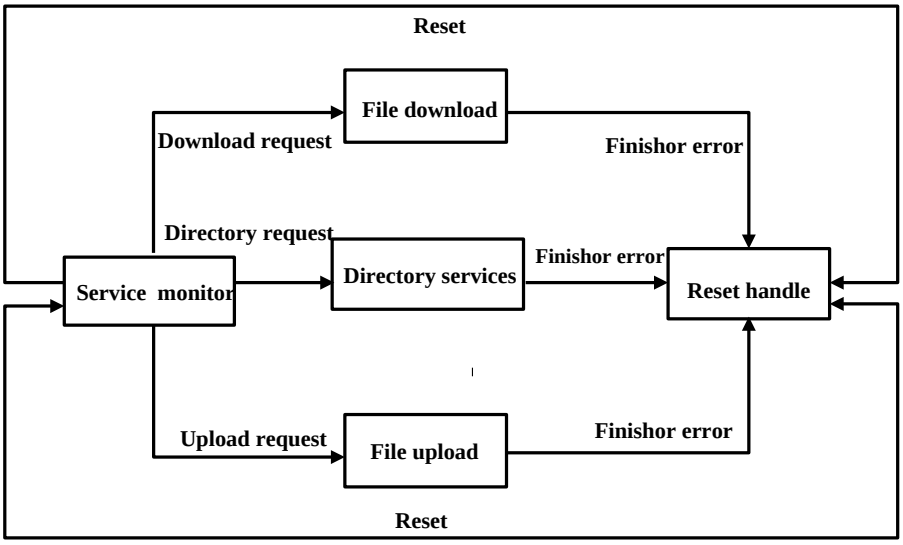


**Figure 6. The State of the File Transmission Server**

## 5. Experimental Verification

The basic agreement of TCP/IP was test through the experiment, access gateway address of ZNE–100TL module is set to the network segment 192.168.0.1, the upper computer using Windows XP operating system and D-Link DFE-530TXPCIFAST Ethernet adapter 10M /100M, IP address of the upper computer was set to 192.168.0.12, communication test is conducted between upper computer and lower computer. The upper computer sent the request message to ZNE–100TL module through command ping192.168.0.1, ZNE–100TL module

 

can respond correctly to the request of the upper computer, the effect is good in the communication process.

## 6. Conclusion

(1) Through experimental test, the communication system solved the problems of information exchange in NC workshop, which provided a method for the NC workshop information integration

(2) The communication system can realize information exchange between the numerical control equipment and CAD/CAPP/CAM center, which is convenient for production management, data transmission and query of equipment failure and maintenance, etc.

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## References

[1] X. Yang, L. Sun and Y. Wang, *et al.* "Research of CNC System of Stretch-wrap Former Based on Main-Subordinate Unit", Manufacturing Automation, vol. 27, no. 4, (**2005**), pp. 19-26.
[2] H. Yu, S. Ruepp and M. S. Berger, "Enhanced first-in-first-out-based round-robin multicasts scheduling algorithm for input-queued swtches", IET Communications, vol. 5, no. 8, (**2011**), pp. 1163-1171.
[3] G. Li and J. Yang, "Development of the PC-based Open Architecture Numerical Control System", Hydromechatronics Engineering, vol. 4, (**2006**), pp. 82-85.
[4] Z. Liang, X. Xie and X. Tang, "Design of the Networked Numerical Control System Based on Industrial Ethernet", Modern Manufacturing Engineering, vol. 1, (**2006**), pp. 38-40.
[5] T. Deng, W. Zhu and C. Yan, *et al.* "Research on a Kind of open Numeric Control System Platform", Modern Manufacturing Engineering, vol. 6, (**2006**), pp. 38-36.
[6] B. Chen, "Real-time Industrial Communication Based on Switched Ethernet", Science and Technology Innovation Herald, vol. 26, (**2013**), pp. 1-4.
[7] A. Zhang, "Web-based Monitoring Technology for Remote Devices", MACHINE TOOL & HYDRAULICS, vol. 41, (**2013)**, pp. 127-132.
[8] P. Li, "Design and realization of Gigabit Ethernet in embedded system", Modern Electronics Technique, vol. 37, no. 12, (**2014**), pp. 4-7.
[9] J.-j. Yu, L.-q. Ye and C.-j. Liu, "Design and realization of a monitor system based on embedded Ethernet for frequency synthesizers", Journal of Terahertz Science and Electronic Information Technology, vol. 11, no. 4, (**2013**), pp. 557-560.
[10] S. Wu, H.-x. Pan and Y. Gao, "The design of ethernet communication system based on TMS320F2812", Machinery Design and Manufacture, vol. 3, (**2011**), pp. 203-205.
[11] i.L Boncagn, A. Barbalace and i.Y Sadegh, *et al.* "Switched Ethernet in Synchronized Distributed Control Systems Using R T net", IEEE Transactions on Nuclear Science, vol. 58, no. 4, (**2011**), pp.1793-1799.
[12] G. Carvajal, C. Wu and S. W. Fschmeiser, "Evaluation of Communication Architectures for Switched Real-time Ethernet", IEEE Transaction on Computers, vol. 99, (**2012**), pp. 1-14.