Design of Host Computer for sonar based on Ethernet

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Abstract. The Host Computer for sonar based on Ethernet is suitable for Single-beam Mechanical Scanning Sonar with a scanning frequency of 675 KHZ and 1 MHz. It is completed by using C# programming language in Windows. The Host Computer based on the framework of C#.Net, TCP, UDP are used to communicate between single beam mechanical scanning sonar and Host Computer. The scan data of sonar can be received by the Host Computer, the functions of setting and query sonar operation parameters are provided. The Host Computer uses two network transport layer protocols, TCP and UDP. Most of the sonar data transmission uses only a single protocol. Finally, the received sonar scanning data will be displayed. Wireshark is used to verify the packet capturing of the transmission process.

1. Introduction
With the development of science and technology, network-based communication is more and more widely used, household appliances and industrial sites are increasingly tending to network. Ethernet communication is gradually used in embedded communication. Compared with serial communication, Ethernet communication has a more flexible configuration, supports multi-threaded data concurrency, better real-time performance, and fewer limitations [1]. Ethernet with general performance can meet reliable communication, and the most important thing is that the speed of Ethernet data transmission is faster and the transmission distance is longer. The Host Computer introduced in this paper realize the data interaction between sonar and Host Computer. The target image can be displayed in the Host Computer interface, accurately and clearly.

2. GENERAL DESIGN

2.1. Requirement Analysis
According to the functional requirements: The data scanned by Single-beam Mechanical Scanning
Sonar needs to be transmitted to Host Computer real-time via Ethernet, the parameters of Single-beam Mechanical Scanning Sonar should be set and queried on the host computer, the target should be visible.

Here, the Ethernet chip selected for the Single-Beam Mechanical Scanning Sonar is CH392. CH392 is an Ethernet protocol stack management chip, used for Single-Chip Microcomputer System for Ethernet communication. The chip support two communication interfaces SPI interface and asynchronous serial port. Controllers such as MCU/DSP/MCU/MPU can control CH392 chip for Ethernet communication through any of the above communication interfaces.

The single-chip microcomputer system can communicate with the Host Computer through the CH392 chip. Data transmission process between Host Computer and Single-beam Mechanical Scanning Sonar, is shown in Fig. 1. DSP is the main data transmission device, stores the data parsed by FPGA in its RAM. CH392 is responsible for transmitting the data stored in the DSP to Host Computer via Ethernet. CH392 uses SPI1 and SPI2 to receive and send data. Among them, SPI2 reads 1Byte data from DSP at a time, SPI2 uploads data to SPI1 once when SPI2 is full of 4Bytes, and then SPI1 transmits data once to Host Computer when SPI1 is full of 1024Bytes.

![Figure 1. Date transmission process](image)

**2.2. Software function**
According to the needs of users, the software function module diagram is shown in Fig. 2.

![Figure 2. Software function](image)

**2.3. Design flow and Program realization**
According to the software function shown in Fig. 2 after the software starts running, it is necessary to first connect the Single-beam Mechanical Scanning Sonar, then set parameters of the Single-beam Mechanical Scanning Single-beam Mechanical Scanning Sonar operation, and next receive the scan data from Single-beam Mechanical Scanning Sonar, display the scan date at last. The flow process of the Host Computer is shown in Fig. 3.
Figure 3. Flow-process diagram

The Host Computer running process:
- Open the software
- Get the local IP and port
- Get the Single-beam Mechanical Scanning Sonar IP and port
- Assign operating parameters to the Single-beam Mechanical Scanning Sonar
- Drive the Single-beam Mechanical Scanning Sonar running
- Obtain Single-beam Mechanical Scanning Sonar scan data
- The received data will be displayed in the form of image

The Host Computer mainly includes three program classes:
- CommCmdAddr_Class.cs: defining parameter ID and parameter name, and corresponding all parameters ID with their names.
- DataTransformation_Class.cs: converting the 32-bit uint32 number uploaded by MCU into float.
- Form1.cs: main program of Host Computer.
- CircularScanControlClass_Class.cs: the received sonar scanning data is displayed in the form of color image.
3. Detailed design

3.1. Network connections
The TCP protocol is selected to realize the network connection [2]. The Host Computer is used as the server, and the Single-beam Mechanical Scanning Sonar is used as the client, respectively. After a three-way handshake is completed, the client and the server can transmit data to each other, as illustrated in Fig. 4.

![Figure 4. Three-way handshake](image)

Implementation process: the C#.Net framework of Visual Studio provides a special Convention for network transmission: socket. Socket is like a gate, and data receiving and sending must go through it. The programming flow of socket is shown in the Fig. 5. First, create a new socket and bind the port number of the Host Computer with it; start the listening function LISTEN(), which can monitor the connection of Server and client in real time. Meanwhile, the ACCEPT() function get the communication request from the client and connect it automatically. When Host Computer Obtaining the IP address and port number of the client by using ACCEPT() function, it will add the IP address and port number of the client to the ComboBox_TargetIP, s list (parameter setting and query need to get the client,s IP address and port number from combobox_TargetIP). After successful connection, the textbox_Tips will show "port number + connection success".

![Figure 5. Socket program flow](image)

3.2. Date collection
There are two ways of data collection: Stream and Dgram[3]:

- Stream
- Dgram
• Stream: a connection-oriented way of data transmission. Data can be accurately transmitted, but the disadvantage is the low transfer data rate.

• Dgram: a connectionless way of data transmission. The advantages include the high efficiency of transmission and good real-time.

TCP cannot transmit Single-beam Mechanical Scanning Sonar scanning data very well because Single-beam Mechanical Scanning Sonar scanning data is large and the transmission process needs a high transfer data rate. The head cost of UDP just needs 8bytes, much less than at least 20 bytes of TCP head cost [4]. Therefore, UDP transmission is much more efficient than TCP transmission. Besides, UDP can ensure the sequence of data frames. Thus the transmission of scanned data adopts UDP protocol, and the format of datagram used is sock_DGRAM.

For transmit data with UDP, we must understand the transmission mechanism of the system. The Single-beam Mechanical Scanning Sonar transmits data to the Host Computer once every 1036 bytes, including 8 bytes of UDP header information and 1024 bytes of Single-beam Mechanical Scanning Sonar scanning data. In C#.Net, the data can be received by setting the buffer array, and the buffer array capacity is set to byte[] UDP_Receivedata = new byte[1048]. When the current data comes up, the buffer array will automatically clear the previous data to accept the current data and continue to repeat this process. Set up a label called Label_FrameNu, which will display the frame number of the current data, as a criterion of successful data transmission.

The flow of the data acquisition program is shown in the Fig. 6. Before using the UDP protocol, Local_UDP_socket should be defined to be used as the entrance of Single-beam Mechanical Scanning Sonar scanning data. The Host Computer needs to bind the local port number to the Local_UDP_socket. Through this step, Single-beam Mechanical Scanning Sonar can know the port number of the server receiving the scanning data. The Host Computer accept the data from the Single-beam Mechanical Scanning Sonar through the Receiveform() function. When the transmission is completed, the socket will be closed.

![Diagram](image)

Figure 6. Data acquisition program flow

3.3. Parameter Setting and Query

Parameter setting and query is the operation of Single-beam Mechanical Scanning Sonar parameters by Host Computer directly. Single-beam Mechanical Scanning Sonar operation parameter data must be accurately transmitted between the Host Computer and Single-beam Mechanical Scanning Sonar, and the value data of a single parameter is small. So the requirement of data transmission efficiency is not so high, the parameter query and setting adopt TCP network transmission protocol.

There are many kinds of Single-beam Mechanical Scanning Sonar parameters, which will cause data confusion if transmitted all at once. Therefore, the Host Computer and Single-beam Mechanical Scanning Sonar need to lay down a parameter transmission protocol as shown in Table. 1. From left to right are parameter ID, parameter length, parameter data type, permission setting, and parameter name.
UDP is used for the transmission of scanning data between Host Computer and Single-beam Mechanical Scanning Sonar, TCP is used for parameter query and setting.

The format of setting parameters:
- packet header (0x43,0x4d, 0x44) + parameter address + parameter value.

The format of query parameters:
- packet header (0x43,0x4d, 0x44) + parameter address + 0x80

Table 1. Communication protocol between parameter setting and query

| ID    | length | Data Type | Access Rights | Note               |
|-------|--------|-----------|---------------|--------------------|
| 0X51  | 4byte  | BCD       | N, Y          | VersionNo          |
| 0X52  | 1byte  | BYTE      | Y, Y          | Distance           |
| 0X53  | 4byte  | Float     | Y, Y          | OpenAngle          |
| 0X54  | 1byte  | BYTE      | Y, Y          | Zoom               |
| 0X55  | 2byte  | Uint16    | Y, Y          | StepInterval       |
| 0X56  | 1byte  | BYTE      | Y, Y          | TRX_Power          |
| 0X57  | 1byte  | BYTE      | Y, Y          | HV_EN              |
| 0X58  | 1byte  | BYTE      | Y, N          | WorkMode           |
| 0X61  | 4byte  | BYTE      | N, Y          | CenterFreq         |
| 0X63  | 12byte | BYTE      | Y, Y          | FreqStart          |

The design of parameter setting and query uses the ComboBox from Visual Studio. All the parameters are written into its drop-down list, as shown in Fig.7, the parameter names from top to bottom are VersionNo, Distance, OpenAngle, Zoom, StepInterval, TRX_Power, HV_EN, WorkMode, CenterFreq, FreqStart.

![Parameters ComboBox](image)

The setting of OpenAngle is taken as an example to illustrate the parameter setting process: Click the parameter setting button to call the program to get the Openangle value that just set and then convert the type of the Openangle value from string to float. Finally, the float data is converted to 32-bit byte array recognized by Single-Chip Microcomputer, and byte array is sent to Single-beam Mechanical Scanning Sonar through TCP protocol. After setting the parameters, the label on the desktop of the Host Computer will display the latest parameter values.

Parameter query: the Host Computer sends datagram to Single-beam Mechanical Scanning Sonar: packet header (0x43,0x4d, 0x44) + parameter address + 0x80. When receiving a frame of data from the Host Computer, Single-beam Mechanical Scanning Sonar sends the current parameter value back, and then textbox_Paravalue get and display the parameter value queried automatically.
3.4. Date display
After the received data is processed, it is converted into the data type that can be recognized by the PC. Use the CircularscanControlclass function to draw a circle with a radius of 400 pixels on the screen, and a total of 360 data frames are used to display the scanned image. Each frame is divided into 400 segments, and each segment takes a data point and punches it on the current pixel. Finally, according to the intensity value of the pixel and the intensity value of the three primary colors in the PseudoColor, the color sonar image about the target is formed.

3.5. Software interface
The Fig. 8 shows the interface of Host Computer operation. Divided into the upper part of the display box and the lower part of the operation box. Including network connection, parameter query and setting (That is the hardware operation part). And you can directly read out the currently set parameter values at the black words in the lower right corner.

4. experimental verification
Wireshark network packet capture software is used to monitor the whole transmission process to ensure the reliability of data interaction. The following is an experimental packet capture data interception to illustrate. In addition, the implementation effect is demonstrated.

Fig. 9 illustrates the data frames captured by Wireshark when the Host Computer connects with the Single-beam Mechanical Scanning Sonar. Seven frames are selected for an explanation. Besides, frame 4 and frame 5 are Single-beam Mechanical Scanning Sonar sending a TCP data frame to the Host Computer, and the Host Computer responding a TCP data frame back to the Single-beam Mechanical Scanning Sonar, respectively, when receiving the data frame. The above process is called heartbeat, which is used to regularly monitor whether UDP data is received by the Host Computer successfully.

Figure 8. Host Computer running interface

Figure 9. Wireshark capture
Fig. 10 shows one frame of data, and each frame of data is 1078 Bytes. Blue is selected, which is 1036 bytes received by the Host Computer, and its specific data format is presented in Fig. 11. It can be revealed that 1078 bytes of data are divided into four parts in Fig. 11.

![Figure 10. One frame data selected](image1)

**Figure 10. One frame data selected**

![Figure 11. UDP transmission data format](image2)

**Figure 11. UDP transmission data format**

Fig. 13 shows the experiment in the East Road Campus of Yunnan University on June 20, 2021. We can see the wall of the LianHua pool, rockery in the pool, fish in the water. The experiment effect is good. Fig. 12 is a picture of the LianHua pool.

![Figure 12. Real picture of experiment](image3)

**Figure 12. Real picture of experiment**
5. Conclusion

After the test, the software runs well, successfully communicates with Single-beam Mechanical Scanning Sonar, and transmits Single-beam Mechanical Scanning Sonar scanning data efficiently. Parameter setting and query function can also be used normally. The display of the target is accurate and clear.

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