DESIGN AND APPLICATION OF HEATING METERING AND MONITORING SYSTEM BASED ON CLOUD PLATFORM

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With the scale of equipment needed to be managed in heat metering monitoring system becoming larger, how to realize simple management and ensure scalability is a problem that needs to be studied.Based on the comprehensive application of information and communication technology, this paper studies and expounds the intelligent management of heat metering based on cloud platform, and analyses and plans the intelligent management platform of heat metering. It is convenient for heating companies to monitor the status of the site, find problems in time and deal with them. It realizes user addition and management and facilitates business expansion. By promoting rational consumption of heat energy, the intelligent management platform of heat metering can realize energy saving, environmental protection, fair trade and make the best use of everything.

Key words: *heating metering, cloud platform*

1. introduction

The so-called heat metering refers to the metering of the heat supply of the urban central heating system and the heat consumption of the heat users. The main purpose of heat metering is to determine the quantity of heat energy produced or consumed, so as to monitor and calculate the efficiency of heat source equipment or as a basis for charging heat fees to heat users [1-3]. It can greatly improve the management efficiency of heat supply and conserve energy, which is of great significance to both users and heat suppliers. In the heat metering system, the heat metering instrument collects and controls the temperature and heat data in real time in units of each household. More and more residential buildings have completed heat metering renovation in China. On the one hand, they save a lot of energy and contribute to the healthy development of society. On the other hand, they make the number of heat metering instruments huger, and make the unified monitoring of these instruments become more and more complex [4,5]. One server is not enough to cope with too many devices. It is necessary to use multiple servers to form a distributed architecture. This is the main reason for complicating the problem. There are two ways of heat metering household, one is to use building calorimeter to measure the building, and then allocate it by arithmetic according to the number and area of households, the other is to use household calorimeter installed in each household to calculate the heat cost directly by household metering.

Cloud computing is a rapidly rising and applied technology in recent years. The National Institute of Standards and Technology of the United States defines that cloud computing isa model that accesses a pool of shared and configurable computing resources (e.g., networks, servers, storage, applications, services, etc.) through ubiquitous, convenient and on-demand networks, and can be quickly allocated or releasedwith very few management operations or service interactions [6]. Using this method, we can design a new heat metering monitoring system to facilitate the unified management and expansion of the whole system, and simplify the problems encountered in monitoring a large number of equipment. The practical application of cloud platform in China is in a period of rapid growth, and the market share is increasing year by year [7]. Since 2009, there has been a real cloud computing industry in China, and some local governments have begun to establish cloud computing centers. Domestic Internet companies, such as Tencent, Sina and Alibaba, have offered relevant cloud services to the outside world in order to improve their efficiency and reform their IT facilities [8-10]. These measures are conducive to reducing the company's costs and expanding the company's business scope. Besides these Internet companies, traditional telecom operators in China have also developed cloud computing related projects one after another in order to keep up with the trend of the times.

In this paper, the overall framework of the system is described in terms of analysis requirements, and the specific functions of each module and the relationship between the modules in the system are explained. This paper mainly describes the internal structure of different modules from the perspective of specific implementation, and discusses the specific implementation methods. At the same time, the simple deployment method of the system is introduced, and the virtual machine environment and database layer are tested.

2. Data Acquisition and Analysis System of Heat Meter Based on Cloud Platform

2.1. Overall structure of heat meter data acquisition system based on cloud platform

Considering the requirement analysis and practical application scenarios, and taking service-oriented as the basic design principle, the system functions are designed according to hierarchical modularization, which effectively reduces the overall affinity of the system, and facilitates the initial design, as well as the later reusability and maintainability [11]. The architecture of Internet of Things includes perception layer, network layer and application layer. Here, the functions of the system are also divided into three levels. From bottom to top, data acquisition layer for data acquisition and control, network transmission layer for reliable data transmission and terminal application layer for users and administrators are in turn.

The main functions of the data acquisition layer can be divided into two parts. One part is that the collector collects heat meter data to upload at a fixed time every day. The other part is that the collector can respond to instructions in real time when the terminal has commands to issue. The main function of the network transmission layer is to use it as a transfer station and base station as the contact point to realize bidirectional signal transmission between the data of the bottom collector and the control instructions of the cloud server. This system uses GPRS communication as the transmission mode of information through the Internet. With the rapid development of Internet of Things technology, GPRS technology has become increasingly perfect, powerful and easy to use. The main function of the terminal application layer is to analyze the data from the data collector and display it to administrators and users. In addition to the database stored in the cloud, this system also designs the web page, which is convenient for users and administrators to query data, issue commands and other operations. Web pages can intuitively carry out various operations of the system. Administrators can provide special services and users' web pages by setting permissions. It not only meets users' own needs in function, but also ensures security and avoids the destabilization of the system due to misoperation or intentional destruction.

2.2. Data acquisition system technology of heat meter based on cloud platform

2.2.1. Cloud storage technology

Cloud storage technology sets of computer devices can be of various types, using distributed file systems, grid computing technology, cluster applications, and providing data storage, analysis and calculation functions. Generally speaking, cloud computing system can be regarded as a cloud storage system when a large amount of data is being stored and calculated in a certain period of time. Cloud storage technology is not only similar to the previous hardware storage technology, but also like a service. It is a collection of multiple device services, not just a device. Similarly, cloud storage technology is also based on the cooperation of a variety of technologies. Only by the cooperation of these technologies can cloud storage function be realized.

2.2.2. Wireless communication technology

System server receives data and sends control flow as shown in Fig.1. Server Socket ports monitor all collectors waiting for connection at the same time. Monitoring terminal sends requests to server through wireless communication module. After successful establishment of Socket channel with server, data can be transmitted on this channel. After the server receives the data, first check the integrity and format of the data, complete and accurate data will be stored in the database, otherwise return to wait for the next connection and upload.

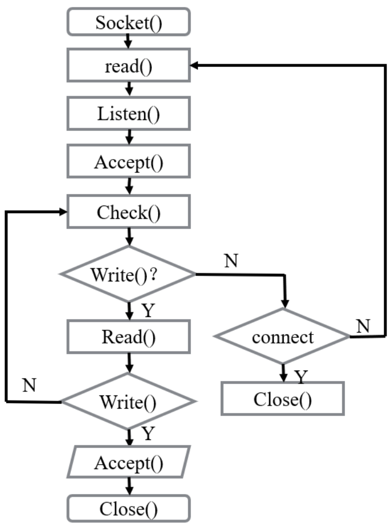

Figure 1 Control flow chart

2.2.3. Communication technology

The terminal heat meter is usually installed in the control cabinet at the user's door. To transmit the data in the table to the collector, wireless and wired methods can be considered. First, a certain number of heat meters are connected to the same collector, and then data processing is uploaded.

M-Bus (Meter-Bus) is a two-wire fieldbus, which adopts European standard and master-slave half-duplex communication. It is specially designed for remote meter reading. Compared with RS485, M-Buscan use ordinary twisted-pair cable, the topology is arbitrary, the construction cost is saved, and the number of slaves is much higher than RS485. It can charge the calorimeter while satisfying the communication, which greatly increases the life of the calorimeter. Therefore, this paper adopts a heat meter with M-Businterface. The performance comparison between M-Bus and RS485 bus is shown in Tab.1.

Table1M-Bus and RS485 bus performance comparison

Performance comparison	RS485	M-Bus
Connection mode	Four-wire system	Second-line system
Communication signal	Differential voltage signal	Downlink voltage signal, uplink current signal
Polarity	Yes	No
Node power supply capability	No	Yes
Topological structure	Star or tree structure	Arbitrary topological structure
Cascade situation	Can't cascade	No series limitation
Cable requirements	Shielded twisted pair	Ordinary twisted pair
Communication distance	1200 meter (Theoretical maximum)	1000 meters (Reliability value)
Load capacity	256 (Theoretical maximum)	300 (Reliability value)

3. Hardware Circuit Design of Heat Meter Data Acquisition System Based on Cloud Platform

3.1. General structure of hardware circuit of system collector

The heat meter collector is based on Freescale MK10DN512VLLH10 (hereinafter referred to as K10) chip minimal system as the control center to collect heat meter data and remote wireless communication. The specific structure is shown in Fig.2.

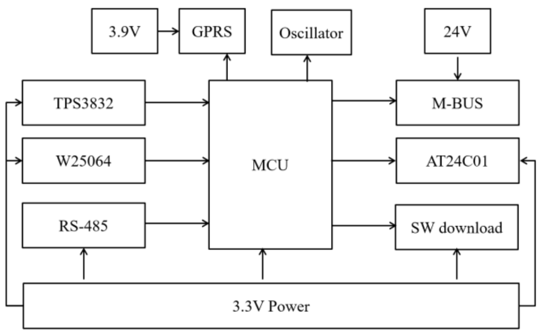

Figure 2 Schematic diagram of collector structure

The minimum system of the single-chip microcomputer is composed of a package expansion single-chip computer, a reset circuit, a crystal oscillator circuit and a SWD interface. The schematic diagram is shown in Fig.3.

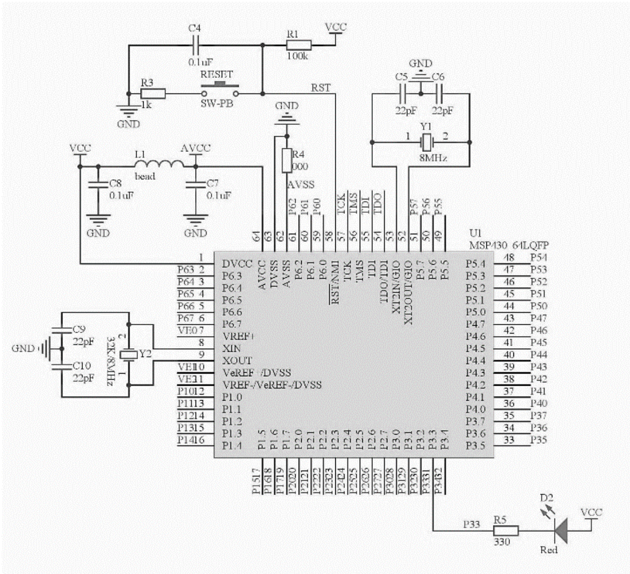

Figure 3 Principle of minimum system of single chip microcomputer

3.2. Design of power supply circuit for collector

3.2.1. Civil electricity treatment

Because the area where the heat meter is located is residential buildings, and the quality of power supply for civil use is poor, so the treatment of power supply is particularly important. The system uses 220V AC, which connectswith circuit breaker and fuse, and addssurge protection device, which can effectively prevent the influence of voltage fluctuation on the heat meter collector. The electrical wiring diagram is shown in Fig.4.

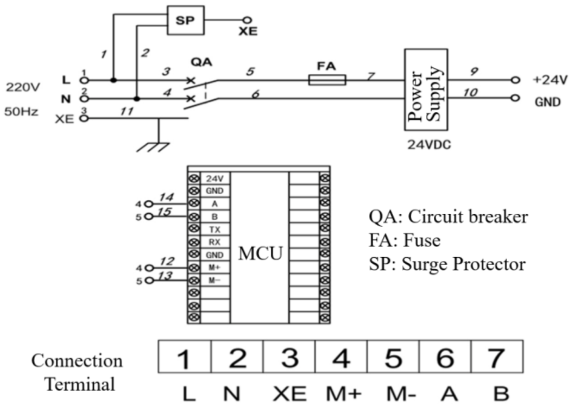

Figure 4 Electrical wiring diagram of power supply

3.2.2. Design of power supply module of collector

After treatment, 220V AC power supply is converted into 24V DC through switching power supply and then supplied to the system. Considering that when GPRS module transmits and receives data, the instantaneous current will increase to about 1A, and considering other module requirements of the system, switching power supply chooses 2A output to ensure the demand of the system. There are three types of power supply requirements for heat meter collector: 1.K10 single chip computer power supply range is 1.7V~3.6V, typical value is 3.3V, so choose 3.3V, at the same time, the system storage module and 485 circuit are all 3.3V power supply; 2.MG301 module power supply voltage is between 3.3V~4.2V, choose 3.9V for module power supply; 3.M-Buslevel conversion module power supply voltage is 24 V, after switching power supply conversion directly. LM2576 chip is used for 24V conversion 3.3V and 3.9V. The schematic diagram of power conversion is shown in Fig.5.

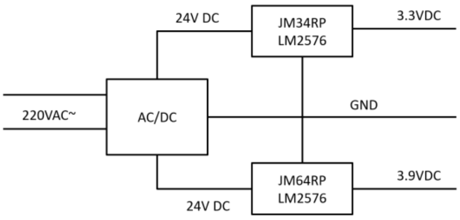

Figure 5 Power conversion diagram

4. Design and Implementation of Data Acquisition System for Heat Meter Based on Cloud Platform

4.1. Heat meter data acquisition system based on cloud platform

Figure 6 is the flow chart of the collecting software architecture. After the collector is powered properly, the system clock, timer, serial port, SPI and other modules begin to initialize. The parameters of meter reading equipment are read from EEPROM. If the parameters of reading equipment are incorrect, the equipment will not work properly. When the collector reads the device parameters successfully, GPRS power on to start the registration 2G network, then set up the Internet communication parameters, open the GPRS data service and establish a connection with the server. When the collector is connected to the server, the MCU detects whether there is data passing through the GPRS module. If there is no data passing through the GPRS module after three minutes, the collector sends heartbeat frames. If there is data passing through the GPRS module, it judges whether the data is table operation or not. If the instruction is not table operation, it is parameter setting operation for the collector.

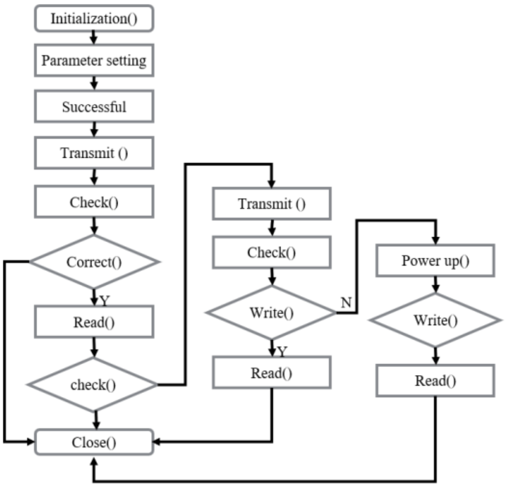

Figure 6 Flow chart of collecting software architecture

4.2. Analysis of calorimeter data

After receiving the reading instruction, the heat meter returns 59 bits of data, including accumulated heat, accumulated cooling capacity, power, inlet temperature, return water temperature and other information. After receiving the data, the collector will judge whether the checksum is correct, then judge whether the table number exists, and then analyze the data. The flow chart is shown in Fig.7.

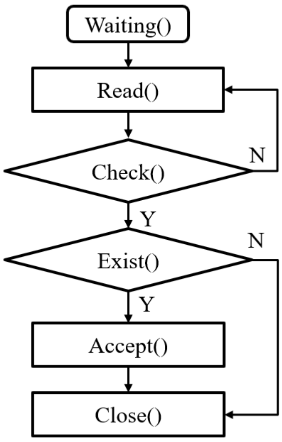

Figure 7 Flow chart of heat meter data analysis

Hot table return data is also returned through the format of the package. It contains important information such as the head and tail of the package, which is convenient for analysis and judgment. The uniqueness of the table number is also an important basis for data not to go wrong and confused. The specific format is shown in Tab.2.

Table 2 Hot table return data format

Byte order	Name	Length (byte)
1-2	Baotou	2
3-6	Table number	4
7-9	Table number fixed number	3
10-14	Fixed code	5
15-19	Cumulative cooling capacity and units	5
20-24	The amount and unit of accumulated heat	5
25-29	Power and unit	5
30-34	Instantaneous flow and unit	5
35-39	Accumulated flow and unit	5
40-42	Water inlet temperature	3
43-45	Backwater temperature	3
46-55	Working hours	10

The units mentioned in the table need to be judged and processed specially. The results of different types of acquisition are different according to different units. The instructions issued and uploaded by the calorimeter are hexadecimal, which also need to be processed in data conversion. The following program shows the power analytic design. Other quantities are similar.

```
//Power analysis
tempdouble=0;
tempdouble=Uart1_Receive[24]/16*10+Uart1_Receive[24]%16;
tempdouble+=(Uart1_Receive[25]/16*10+Uart1_Receive[25]%16)*100;
tempdouble+=(Uart1_Receive[26]/16*10+Uart1_Receive[26]%16)*10000;
tempdouble+=(Uart1_Receive[27]/16*10+Uart1_Receive[27]%16)*1000000;
//Unit Conversion
switch(Uart1_Receive[28])
{
case0x14://141W
tempdouble=tempdouble;
break;
case0x15://1510W
tempdouble*=10;
break;
case0x16://16100W
tempdouble*=100;
break;
case0x17://171kW
tempdouble*=1000;
break;
}
//Unit Conversion End
Meter_Data[i].Power=tempdouble
```

4.3. System testing

4.3.1. Virtual machine environment testing

In this project, because each data collector needs to set up a separate thread, so as the number of data collectors increases, the number of threads in the whole system will also increase.In the JVM environment of virtual machine, the number of threads that can run stably is closely related to the parameter setting of JVM. The main parameters involved are Xms, Xmx and Xss. Xms is the maximum memory size that can be used, and if it exceeds that size, an exception will be thrown. It represents the maximum memory that a program can use, so it is related to the number of threads running stably at the same time. Xmx is the size of memory used initially. Since the number of devices responsible for the heat metering device communication program in each virtual machine in this project is determined, the number of threads to be run is known at the beginning of the start of the heat metering device communication program, so Xms and Xmx can be set to the same size. Xss is the stack size of each thread. If the settings are too small, overflow will occur, and if they are too large, memory may be wasted. It determines the size of memory occupied by each thread and the number of threads running stably at the same time. In the virtual machine environment, after testing, the relationship between the size of Xss and Xmx and the number of threads that can run stably at the same time is shown in Fig.8.

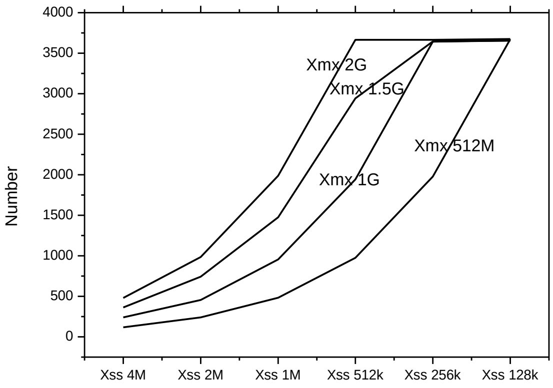

Figure 8 The relationship between the size of Xss and Xmx and the number of stable running threads

As we can see from the figure, the number of threads that can run stably at the same time in the virtual machine is increasing as each thread stack (Xss) decreases and the maximum memory (Xmx) available to the JVM increases. But once the number of threads exceeds 3600, even if Xss continues to decrease and Xmx continues to increase, the number of threads does not change, but stabilizes between 3600 and 3700. Therefore, in the running environment chosen by this project, the number of threads that JVM can run stably at the same time is less than 3600.

4.3.2. Database layer testing

When the number of devices is very large, the database layer is also a distributed architecture. During the test, the project selected two database servers and wrote the test program separately. A large number of device data were written to the queue to be written to the data exchanger at one time, and the writing time was recorded. The number of threads in the data exchanger was set to 100. The writing performance of one server is compared with that of two servers. As shown in Fig. 9, the horizontal axis is the number of data bars written in one time and the vertical axis is the multiple relationship.

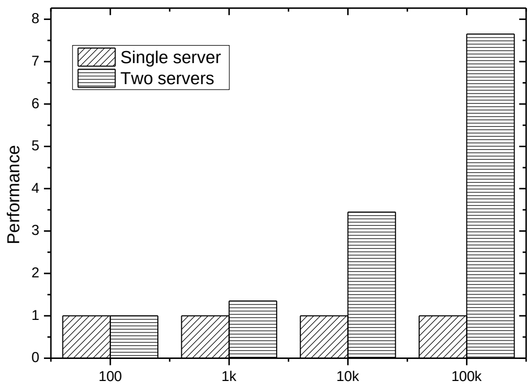

Figure 9 Performance comparison of single server and two servers in database layer

As can be seen from the fig. 9, when the amount of data is small, the pressure on the database layer can be neglected. The performance difference between one server and two servers is not big, but with the increase of the amount of data, the gap between the two servers begins to increase. When the amount of data is very large, the efficiency of two servers is almost twice that of a single server.

5. Conclusion

After investigating the existing remote meter reading system in China, this paper improves the existing system, uses M-Buscommunication as fieldbus, and uses GPRS technology to realize remote wireless communication. The cloud platform ensures the security and reliability of data, and improves the computing ability. In addition, the design of web page provides a visual platform for monitoring and management. This paper introduces the function realization of each part of the system from the software point of view. It mainly introduces the data package format of M-Buscalorimeter acquisition instruction and return data, GPRS module parameter setting, connection process and data interaction. The upper computer analysis introduces the function design and realization of server, database and web page. After testing, the function of the system is basically perfect and has been put into use. In this paper, the deployment of cluster and user graphical interface are introduced, and the system test is carried out. Through testing, the relevant parameters of virtual machine environment are determined, and the system efficiency is guaranteed without affecting the stable operation.

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