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Design of Test Platform for Concentrator based on Virtual Electric Energy Meter

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Abstract

For the current test of concentrator relay routing learning function in the laboratory, based on the hardware cost and the deployment environment, unable to realize large-scale electric energy meter group network, and real scene environment cannot be simulated. In order to solve these problems, the design of test platform for concentrator based on virtual electric energy meter is proposed in this paper. The design aims to simulate the communication routing network algorithm of electric energy meter and help the communication instruction to establish an optimal topology network which through using the specified data source, target source and the route address. So the concentrator can get the specific data through this preset network. This paper have also observed and analyzed the hierarchy order topology and compared with the autonomous learning topology of the concentrator relay routing algorithm. Then verify the deviation between communication routing topology and preset value, and eliminate the deviation. At the same time, verify whether the relay routing algorithm can get the optimal communication topology network.

Keywords*: communication network, relay routing, test platform for concentrator*

1. Introduction

Electric energy meter is the information exchange window between power grid enterprises and power users, which is directly oriented to electric power users, it is responsible for the electric power user's electricity consumption information collection [1].The automatic meter reading technology is developed on the basis of the electric information acquisition system, which affects the quality of life of the residents. In the 1970s, the technology of Automatic Meter Reading(AMR) has been studied abroad. By the mid-1980s, the United States, France and Japan and other countries put the AMR system into regional to carry out a trial. After entering 21th century, wireless technology of meter reading system has become more and more mature, and smart meter reading system has become a very important part of the construction of smart grid. Britain has basically realized the automatic collection for power consumption information of industrial and commercial users and some residents[2].

Since the 1990s, the development of AMR technology in China has experienced three stages, from trial-produce to gradually mature. In recent years, many provinces and cities in China have gradually started the application of AMR system, the technology of AMR in our country is developing in the direction of more intelligent.

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Due to environment limitation in many areas, we still mainly take the way of manual meter reading [3].As a result, the electric information acquisition system, which is developing rapidly in recent years is of great significance for China's construction of smart grid, intelligent community.

As an important terminal device for electricity power information collection system of power consumers, concentrator is responsible for collecting a large number of energy data of energy meter, processing and storing data and then transferring to master station. Meanwhile, concentrator is also in charge of conveying orders from master station to energy meter. So the concentrator is an important part in meter reading, it plays a connecting role[4]. Therefore, it's an indispensable link to test the concentrator's function before the net.

At present, concentrator test mainly concentrates in the laboratory, a small amount of electricity energy meter can be used during the test. But the grid condition of the laboratory is better than that of the district, and all kinds of power grid noise is very small, cannot effectively reflect the problems of some complex environment. And it needs to remount different electric energy meter if you test carrier of different protocol, so the concentrator test in laboratory cannot fully simulate the complex scene [5]. Based on this background, a virtual test platform for concentrator is proposed.

Through simulating the actual power grid environment, this system will be able to simulate power information of a large number of electric energy meter without going to the scene. The actual communication success rate of meter and the relay route [6] between meter will be preset according to the simulation of communication status of the scene environment. The system provides feasible simulation data, we need not go to the complex scene to debug in the development phase, so as to improve the efficiency of testing and reduce the cost of development.

Briefly, this paper consists of five parts. Firstly, the thesis elaborates the background and significance of the research. The second part of this paper introduces the realization of the system function. The third part tells the design of system architecture. And the fourth part describes the design of database system. Finally, this paper analyses the test result when the system is put into operation.

2. The Main Function Design of the System

According to the various parameter which are input in advance, the virtual test platform simulate the real electric energy meter as much as possible in the real operation situation in grid environment. This provides test environment and data-processing conditions for concentrator's operation. Main function is embodied in the following points:

(1)The virtual test platform can simulate multiple transformer districts, 1000 pieces of various types of meter can be simulated in each district, and the types of meter include: card meter, terminal voltage monitor, multi-function meter, ordinary meter and assessment meter. So we can see the impact on the concentrator reading when several districts exist at the same time.

(2)The success reading rate of concentrator is set on the virtual platform, and set the response frame at the same time. In order to simulate the scene that some meter don't response to concentrator when interference existing in transformer district.

(3)According to the routing table of concentrator, the virtual test platform automatically set relay node for the destination node from levels 1-7. Meanwhile, the communication status between two relay nodes is set up[7]. In order to simulate the situation that concentrator can read through relay routing.

3. The Structure Design of System

The virtual test platform for concentrator communicates with the concentrator through read controller, as shown in Figure 1. The test platform communicates with read controller by RS232, and the read controller only completes the work of the conversion between data of RS232 and data of power line carrier. Using C/S mode in the structure of system software, and the design idea of WebUI is adopted in the interface design.

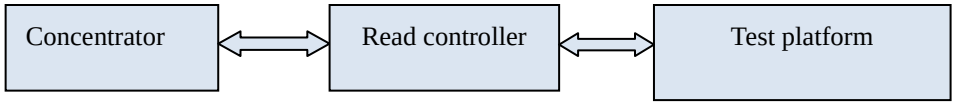

Figure 1. The Whole Structure of System

It may cause unable to communicate by factors such as the interference of low voltage power line, communication signal attenuation[8] and long distance between electric energy meter and concentrator. It's useful for data forwarding to add relay nodes between electric energy meter and concentrator. Self-learning routing algorithm of concentrator must traverse all paths, inductive and remember all feasible paths. Then select the best path based on some rules.

The system simulate the communication in power network[9], the carrier command frame which are sent out by concentrator reaches the target meter through multi-level relay routing of the virtual electric energy meter, eventually the concentrator receives the returned data frame. The whole communication process is very complicated, and it needs to test a number of links, and take into account the subsequent maintenance, such as protocol extension and so on, so it is necessary to design a hierarchical global framework. The overall framework is shown in Figure 2.

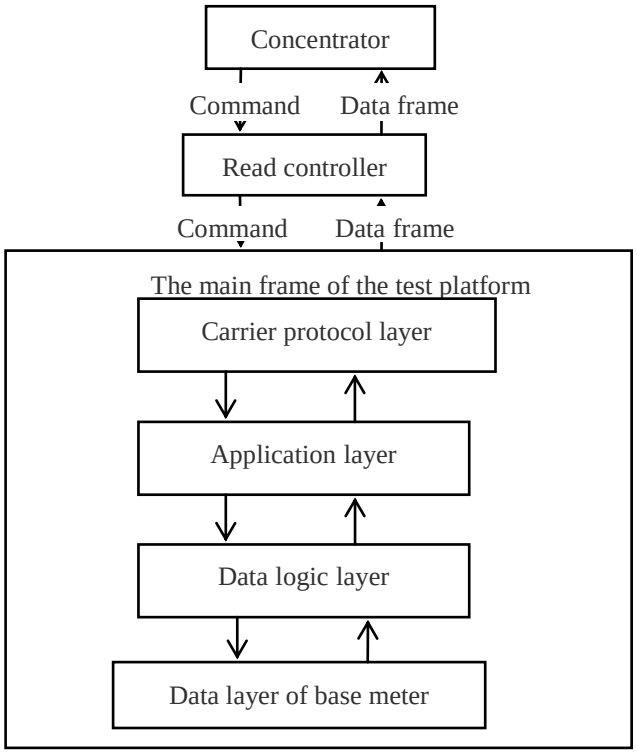

Figure 2. The Main Frame of the Test Platform for the Concentrator

First, the carrier protocol layer is triggered. The length of the serial port buffer was being cleared which to be prepared for subsequent reception. According to the current supported protocol type, carrier protocol layer will verify the validity of data, parse target meter number, router information, reading contents, then trigger the application layer to deal with current command. If the carrier protocol layer receives the successful response from application layer. Then data frame will be organized according to the protocol and being stored into serial buffer, triggering the sending task of serial port[10].

When application layer received the request from carrier protocol layer, then it will judge whether the target meter number exists and the direct reading or relay route is connected. The application layer will send data requests to the data logic layer when the conditions is meets or directly returns failure response to carrier protocol layer when not meets. After getting the returns data from data logic layer, the application layer will reply success or failure response to the carrier protocol layer[11].

The data logic layer will check the validity of data identification according to the current protocol. If the validity check passed, then extract all needed basic data from the data layer of base meter and returns the organized data to application layer.

The data layer of base meter manage a batch of electric energy meter in virtual power grid, which could be read by concentrator. The operation parameters and status needs to be set in advance. The data layer of base meter is responsible for simulating the various data of local electric energy meter.

4. Database Design

Design of database logical is shown in Figure 3.

Figure 3. Entity Relationship Diagram of the System

Database of meter's number has stored all meter's number of current test concentrator. It's used to check whether the target meter's number and relay meter's number in the carrier are right. When the system is running, data will be loaded from the configuration file or database to be used as the original data for a single base meter. The timer triggers the base meter to calculate the data, and then shifty simulation data is generated. Method of additional process is used for database to connect storage and log storage. The design of database in this system follows the principle of "paradigm three". It increases association between the primary key and foreign key in physical. Abstract and classify the data which generated in the system.

5. The System Test and Result Analysis

The hardware of the virtual test platform is consist of computer, concentrator of power line carrier, read controller, all kinds of gauges and other components. Development environment uses Windows XP、MS SQL2005 and VS2008, the running environment uses the operating systems of windows series 、MS SQL2000/2005, the programming language uses C# and SQL. Using C/S mode in the structure of system software[12].

The main window as shown in Figure 4 after system is running. The interface of parameter setting mainly adopts the form of solution, that each solution corresponds to a series of parameter setting. After the main form log in, it uploads data of large quantities of electric energy meter from database.

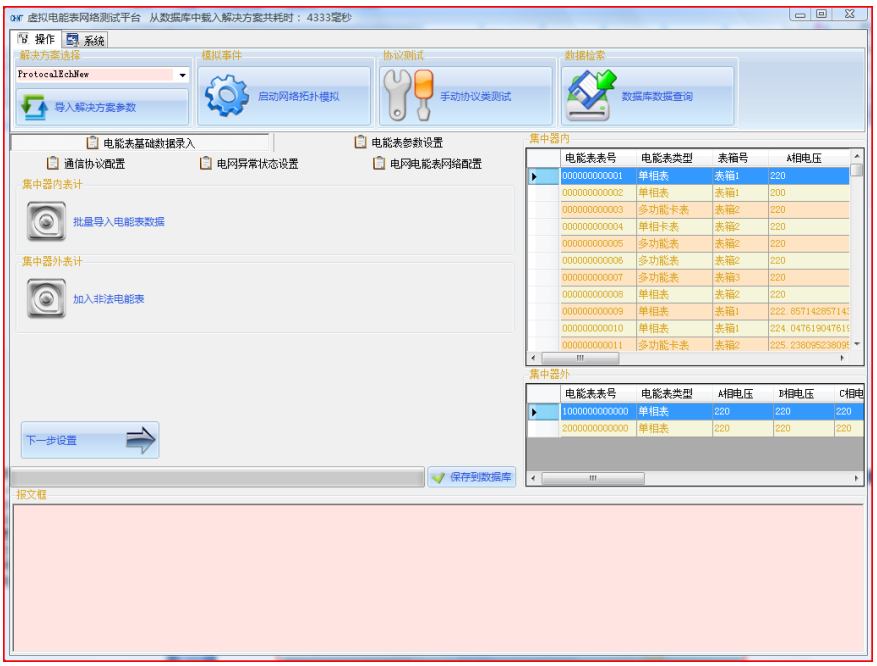

Figure 4. Main Form

Then click the button of grid electric energy meter network configuration, popping the window of network routing, as shown in Figure 5. Its function is to open communication to monitor the meter. Record running time, parse frame and group frame. Here to add theoretical communication route of concentrator, the path which is set by system can be connected. It will add the required meter to be routing meter in each communication path, and the connection percentage of each node in each communication path is set. For example, set 000000000001 as the target meter, set

000000000003 as the first routing meter, set 000000000002 as the second routing meter. Here set the loopback percentage of each node in 321 is 100%, the connection percent of the nodes in other paths is set from 0 to 90%, including the successful connection rate of direct reading is set as 50%. In theory the concentrator will eventually choose the path whose successful connection rate is the highest. This path is 321.

Finally click on the start button, the system turns into the network analog state of meter. When the target meter is directly read, judge whether the target meter can communicate due to the successful communication rate of the meter. When the target meter is read through the relay routing, and judge the successful communication rate of routing meter and communicate status between relay meter, the routing process is shown in Figure 6.

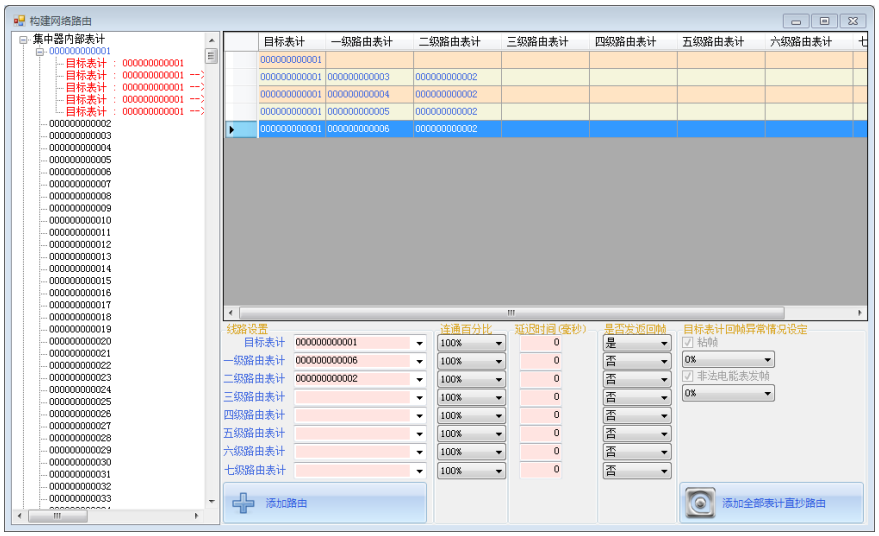

Figure 5. Network Routing Window

On the other side, concentrator starts to traverse all paths in power grid, including the route without adding in system. The process is as follows: the concentrator sends out command frame. It indicates which piece of target meter to be read. It will choose direct read if it can get meter's data directly. On the contrary, it will choose the way of relay routing if the direct read cannot get the meter's data. The first routing meter will judge which target meter will be received the frame through parsing frame if it is successfully connected, or not. After parsing, the first routing meter will transmit the frame to the next routing meter when it has completed frame processing. The next routing meter will work like the last one, if there is a routing meter cannot be connected, it returns failed to the concentrator. Consequently, the concentrator will choose other path until it finds the routing topology which can be able to read the target meter's data. Then concentrator will record the routing topology and stores it in its buffer. Each recorded route will be repeated 100 times. Finally concentrator stored the route with the highest ratio in successful reading route.

During the test, the concentrator sent out a command frame for reading 000000000001 meter directly, but it's failed to get the meter's data. So the concentrator starts to traverse each relay routing. According to the communication success rate of each route, finally the concentrator always sends the same command frame, when it wants to read 000000000001. Through the analysis of the frame, the target meter is 000000000001, the first routing meter is 000000000003, and the second routing meter is 000000000002. In the beginning, the first routing meter

can't communicate with the second routing meter, so the concentrator sent three command frames successively. Until the command frame received by the second routing meter. The result shows clearly that this communication is successful. So the target meter returns response frame to the secondary routing meter, the secondary then returns to the first routing meter, and the last routing meter returns to the concentrator, this is the successful process of reading.

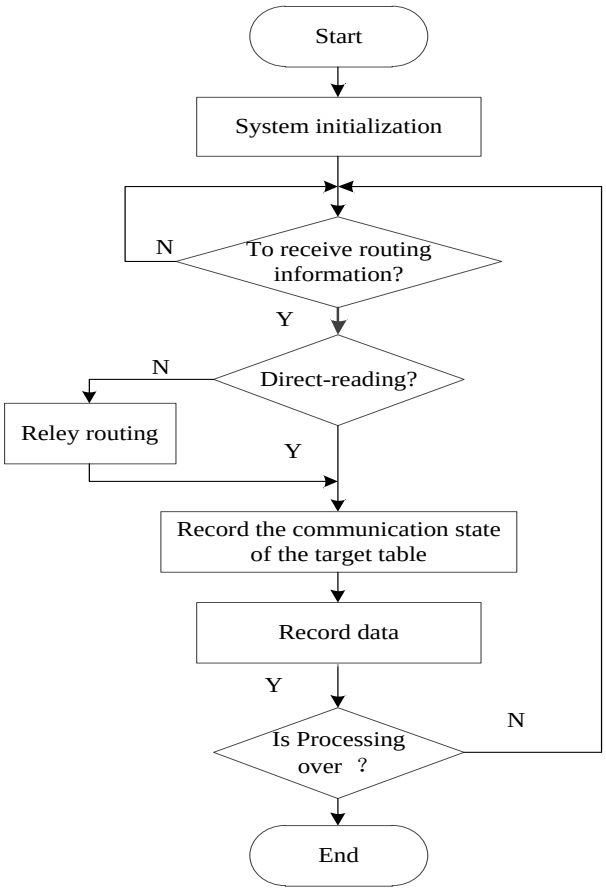

Figure 6. Process of Routing Parsing

The following form displayed the frame data received and forwarded by the routing meter as well as the target meter more intuitively, as shown in Figure 7.

电能表表号	接收帧	接收时间	发送帧	发送时间
000000000003	FFCA170000000000030000000000020000000000016801024 3C35716	2015/12/20 12:51:55		
000000000003			FFC9110000000000020000000000016801024 3C34D16	2015/12/20 12:51:55
000000000003	FFCA170000000000030000000000020000000000016801024 3C35716	2015/12/20 12:52:08		
000000000003			FFC9110000000000020000000000016801024 3C34D16	2015/12/20 12:52:08
000000000003	FFCA170000000000030000000000020000000000016801024 3C35716	2015/12/20 12:52:09		
000000000003			FFC9110000000000020000000000016801024 3C34D16	2015/12/20 12:52:09
000000000002	FFC9110000000000020000000000016801024 3C34D16	2015/12/20 12:52:09		
000000000002			FFC80B0000000000016801024 3C34416	2015/12/20 12:52:09
000000000001	FFC80B0000000000016801024 3C34416	2015/12/20 12:52:09		
000000000001			FFC80F0000000000016881064 3C33B333333A016	2015/12/20 12:52:09
000000000002	FFC80F0000000000016881064 3C33B333333A016	2015/12/20 12:52:09		
000000000002			FFC9150000000000020000000000016881064 3C33B333333A916	2015/12/20 12:52:09
000000000003	FFC9150000000000020000000000016881064 3C33B333333A916	2015/12/20 12:52:09		
000000000003			FFCA1B0000000000030000000000020000000000016881064 3C33B333333B316	2015/12/20 12:52:09

Figure 7. Meter's Frame Data

Through multiple tests, the direct-reading and other low successful communications rate of relay route was been given up by concentrator automatically. And then the communication routing of 321 was been use to read every time for concentrator. This is the same as the highest success rate of communication routing that we set in theory. This is proved that through routing learning concentrator can obtain the best routing.

6. Conclusion

Because of the imperfection that concentrator test in laboratory cannot fully simulate the fact in district which has complex environment, this paper designed a test platform system for concentrator. At the same time, this paper finished the system structure design, function design and database design. The whole system software was compiled under the guidance of system design scheme. This design verified the meter reading function, that concentrator mainly take the method of relay routing in low communication success rate of direct-reading. This system has three evident characteristics in promoting the development of concentrator. First, This system simulate the management of electric energy meter, so it improved the test efficiency which means no longer need to connect the different types of real electric energy meter. Second, the system simulates different type of electric energy meter data and could change constantly as the change of time. This data is similar to the actual data which make the test reliability improved. Finally, this system proved that the concentrator's meter reading success rate can be improved through the relay routing learning function.

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