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Research of Communication Protocols for Energy Metering Devices

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Abstract. In this paper, we will design a set of standard communication protocols that can be used in different electric energy metering device environments by analyzing the communication protocols of the most used electric energy metering devices in the context of IoT smart laboratory construction, so that the electric energy metering devices can automatically detect the inspected equipment. It achieves the purpose of promoting the construction of a smart laboratory, enhancing the management of electric energy metering devices, and improving the efficiency of metering activities. It provides strong support for forming an automated, intelligent and industrialized testing system.

Keywords. Internet of Things, smart laboratory, automatic detection, communication protocol

1. Introduction

Based on Internet technology, supplemented by network communication technology, a network bridge is established between the electrical energy metering device with certain digitalization and the wisdom laboratory, and through this bridge to achieve the function of extracting device data, automatic detection, automatic identification, and automatic control device. With the continuous development and progress of information technology, many occasions have realized the transformation of wisdom. The laboratory is important for carrying out quantity transmission and quality inspection business. It is crucial to recognize the smartness of the laboratory. A series of functions such as receiving tasks, automatic testing, and uploading testing data of energy measurement devices have become essential cornerstones of intelligent laboratories. Therefore, this paper conducts a study on the communication protocols of metering devices.

2. Status of research on communication protocols for energy metering devices

Electricity metering devices are mainly tested for various types of high-precision energy meters. The testing work is carried out with the manual participation of many laboratory personnel, which leads to significant errors in the testing data, incomplete data reporting, subjectivity and randomness, poor timeliness, low accuracy of metering equipment and high error rate. To ensure accurate data, need to repeat the test several times, resulting in

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duplication of personnel efforts, and there are certain safety hazards when testing. Because of the above problems, the design detection process starts from the receiving task of the metering equipment to the end of the task. It performs operations such as automatic data collection, detection, feedback, control, data upload, and real-time monitoring to solve these problems.

In the research, it is found that there are many problems with the current electric energy metering device. First of all, each company's electric energy metering devices use their protocols. Secondly, due to different models and production dates of the same company, the communication protocols of electric energy metering devices will also be slightly different and incompatible, resulting in a large number of electric energy devices. The protocol needs to be parsed before use. The operation and maintenance of the communication protocol of the power metering device are significantly increased in realizing the smart laboratory. As time goes on, the communication protocol will be bloated, so it will take a lot of time, energy, and money to maintain the communication protocol of the electric energy metering device. It will also cause difficulties in integrating the resources of the entire metering industry.

3. Analysis of the current situation of the communication protocol of the power metering device and the design of the standard communication protocol

3.1. Research and analysis of communication protocols of power metering devices with high application volume at present

Taking the communication protocol messages of Sida, ZERA, Sanhui, and Kelu electric energy metering devices as an example to analyze: Sida controls the source cabinet, error cabinet, and standard meter through a communication serial port, and the control source cabinet, error cabinet and standard meter all execute the same Command protocol, the format is the same, the meaning is the same; ZERA controls the source cabinet through a communication serial port and controls the error cabinet through a communication serial port, and the error cabinet communicates with the standard meter. The control source cabinet, error cabinet, and standard meter are different. Command protocol, the format is the same, but the meaning is different; Sanhui controls the source cabinet through a communication serial port and a communication serial port control table, sharing the same set of command protocols; Kelu controls the source cabinet through a communication serial port, and handles the error cabinet through a network cable. A standard set of command protocols. It can be seen from the above four message communication methods that different manufacturers will derive other message communication methods, resulting in the problem of adaptation when connecting to other power metering devices when building a smart laboratory. The specific communication format of each manufacturer is as follows.

The Sida communication protocol is represented as a stream of hexadecimal bytes. The first byte is the functional unit category code. The second byte is the serial number of similar functional units (slaves). The first two bytes together constitute the address code. The third byte is the message length value. The fourth byte is the command code, the subsequent bytes are the specific values of the command code, and finally, the checksum byte is used to end. The checksum is the single-byte hexadecimal data obtained by adding up the contents of each byte of the message frame sent by each communication (excluding the address code, message length, and checksum itself) byte by byte and discarding the rounding value. The message length is equal to the number of bytes in the message frame except for the "address code" and "frame length value" (including the checksum).

Address + Message Length + Command Code + Value + Checksum

The ZERA communication protocol is displayed in ASCII to hexadecimal, ending in 0D. A control protocol is created by splicing command codes and values.

Command Code+Value+0D

The Sanhui communication protocol is displayed in ASCII to hexadecimal and ends with 0D. Command codes and values are spliced into one control protocol.

Command code: Value+0D

The communication protocol of Kelu is displayed in a hexadecimal byte stream, which is divided into the fixed frame and variable frame. The fixed frame takes 10H as the frame start symbol, the second to fifth bytes are the terminal address, the sixth byte is the function code, and finally, the check code and the 16H frame end symbol are concatenated; the variable frame takes 68H as the frame Start symbol, the second to third bytes are the frame length, the fourth to seventh bytes are the terminal address, the eighth to eleventh bytes are the control field, plus the data field, check code and 16H terminator.

Fixed frame. 10H + terminal address + function code + check digit + 16H

Variable frame. 68H + frame length + terminal address + control field + data area + check digit+16H

By parsing and reassembling the communication protocols, the upper computer will receive tasks and then carry out automatic testing and upload test data after the testing is completed. The existing devices will also have the ability to carry out the entire testing process.

From the above, it is clear that the communication protocols of each device manufacturer are very different in detail, which makes it much more challenging to connect the energy metering devices to the smart lab, so it is urgent to unify the protocol messages.

3.2. Design of unified standard communication protocol for electrical energy metering devices

Faced with the existing situation, dismantling, analyzing, and integrating various types of protocols, following the object-oriented principle, and formulating a set of standard communication protocols for electric energy metering devices, require unified management of the communication protocols electric energy metering devices. The automatic detection is divided into the following steps. Each step includes actions such as start, stop, and the status query.

3.2.1. Device initialization

The initialization of the electrical energy metering device allows the device to have certain standardized initial values and resets the calibration parameters that were not restored in the last inspection test.

3.2.2. Initialization of Meter Bits

The initialization of the meter positions allows the device to identify which meter position has a device to be detected and which has no device to be detected.

3.2.3. Device output

The device's output voltage, current, frequency, phase line, and other parameters control powering up and powering down the source and meter.

3.2.4. Device output query

The current real-time status of the device, such as voltage, current, frequency, active power, reactive power, apparent power, three-phase phase voltage, and three-phase phase current, is obtained by querying the output of the device.

3.2.5. Testing test selection

Start the selected test by selecting the test item with the test item-specific parameters.

3.2.6. Test result query

The query of the test results queries the data of the test results.

3.2.7. Stopping the test

Ends the test by sending a stop test command.

3.2.8. Device shutdown

Force the current test to stop, resume initialization, and power down by sending a device shutdown command.

3.2.9. Real-time monitoring

Use the form of an external monitoring device. Monitor the device status in real-time, such as voltage, current, detected results, etc. Then, after the real-time state data model analysis, an automatic warning or forced stop after the device exceeds the limit to avoid damage to the device in the over-limit state. The real-time state data model is a data model for judging electric energy metering devices trained based on a large number of data sets under the framework of deep learning. The basic structure of the deep learning neural network is shown in the following figure.
Neurons. Each node in a neural network is called a neuron and consists of two parts.
Weighted sum. The Weighted sum of all inputs.
Nonlinear transformation (activation function). A nonlinear function transforms the result of the weighted sum to give the neuron computation a nonlinear capability.
Multi-layer connection. Many are arranged at different levels to form a connected multi-layer structure called a neural network.
Forward calculation. Calculating the output from the input, in order from before to after the network.
Calculation chart. Graphically presenting the computational logic of a neural network is also known as a computational graph, which expresses the computational graph of a neural network as an equation.

$$Y = f3(f2(f1(w1 \cdot x1 + w2 \cdot x2 + w3 \cdot x3 + b) + \ldots)\ldots)\ldots)$$

Loss Value. A value that measures the difference between the predicted and true values of the model.

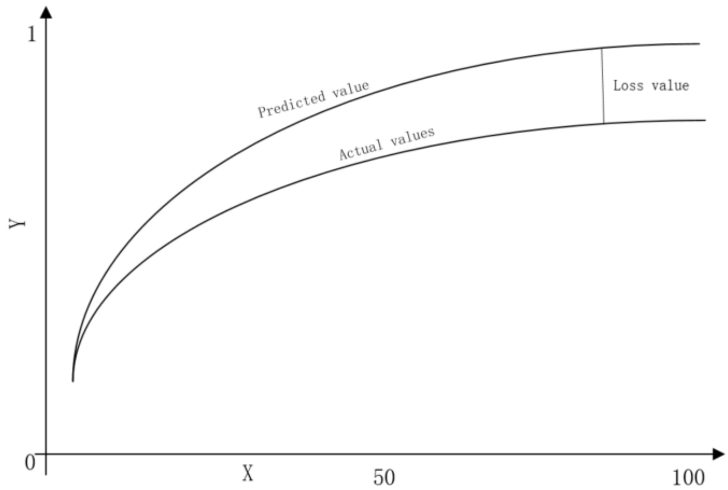

Figure 1. Loss Value chart

3.2.10. Testing process

According to the above design, a whole test process is constructed. In the basic error test, as an example, the device is initialized first. Then the epitope is initialized after the device is initialized. Then the source is upgraded, the error test is performed, and the error data generated in the error test is read simultaneously. And then lower the source, carry out the second set of error tests, repeat the test of all detection points until the detection is completed, and stop the test and turn off the device. The whole test process is equipped with an external real-time monitoring device to monitor the whole process of the electric energy metering device. The specific flow chart is shown in the following figure:

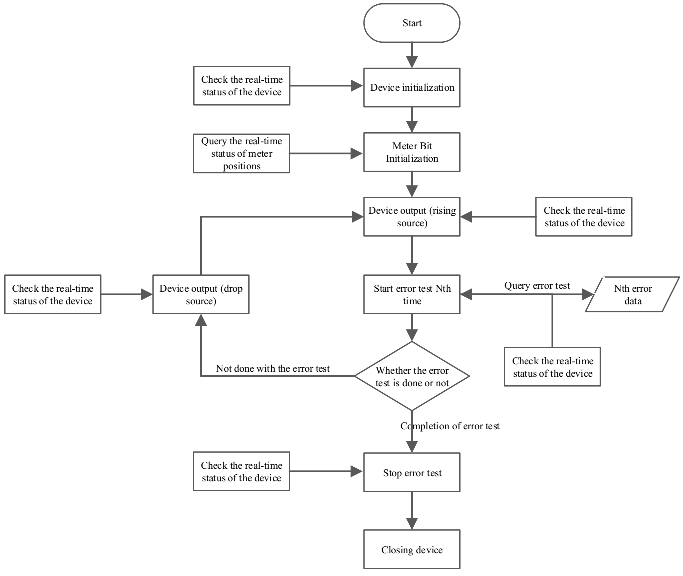

Figure 2. Detection flow chart

3.3. Communication protocol format of power metering device

Develop a unified device communication protocol to send commands to devices in JSON objects. Control of energy metering devices in attribute names and attribute values. Applying an object-oriented form can significantly improve the scalability of the protocol.

3.4. Metering device communication frame diagram design

In constructing the whole intelligent laboratory, the upper information system sends the testing task to the upper computer. The upper computer sends the testing instruction to the electric energy metering device for testing according to the dismantling of the testing task. The electric energy metering device transmits the testing result back to the upper computer, which is assembled into structured data to the information platform, forming a closed-loop data chain to realize the networking work of the electric energy metering device.

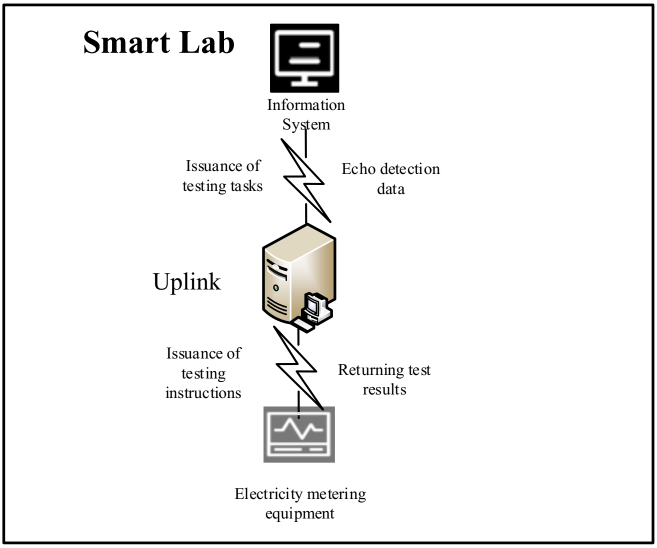

Figure 3. Metering device communication framework diagram

3.5. Design of automatic detection of metering devices

After 2.2-2.4, design, integration, and understanding can automatically detect the electric energy metering equipment. The testing task is sent by the testing personnel using the information system. After the upper computer analyzes and decomposes it into specific testing steps, as shown in 3.2, it sends particular testing instructions to the electric energy metering equipment to automatically test the inspected equipment. The electric energy metering equipment will send the process data back to the upper computer during the test. The electric energy metering equipment will send the test result data back to the upper computer. After analysis, integration, and processing, the upper computer will transmit all data to the information system.

3.6. Test results and analysis

Using 10 sets of electrical energy metering equipment to 1000 sets of tested equipment as a benchmark, for 54 days, 1 set of electrical energy metering equipment to test an average of 100 sets of tested equipment, each electrical energy metering equipment using the original test method and the current test method to test 500 sets of tested equipment respectively.

Efficiency. 500 units of inspected equipment with the original detection method to complete the time of about 20 days, 1 day can test about 25 units of equipment; 500 units of testing equipment with the current detection method to complete the time of about 16, 1 day can test about 30 units of design. The current detection method is 20% more efficient than the original.

Accuracy. The original test method will have 8 times of excessive deviation of error results in every 100 tests; the current process will have 2-3 times of excessive departure of error results in every 100 tests. The current testing method is 69% more accurate than the original.

In terms of personnel, the original detection method requires 5 people to use 10 electric energy measuring equipment, and one person operates 2 electric energy measuring equipment on average; the current detection method uses 2 people to prepare a plan, which can operate 10 electric energy measuring equipment, and one person operates an average of 5 electric energy measuring equipment metering equipment. The current detection method is 250% higher than the original detection method.

4. Advantages of the newly designed standard communication protocol

4.1. Reduce the workload of testing work

The information system automatically configures and issues inspection tasks. The inspection tasks contain the required inspection plans. The operator only needs to review the inspection plans to perform automatic inspections. After the detection test is completed, there is no need for staff to manually enter the detection data and then upload it to the information system. The device automatically uploads the data. This scheme greatly reduces the detection work for the bottom and the data entry work for the top.

4.2. Reduce operation and maintenance costs

Adopt standard communication protocols for new metering electric energy devices to facilitate management. There is no need to face different versions of communication protocols of each company, a set of standard communication protocols to manage all metering electric energy devices, reduce the duplication of development work, and reduce the cost of development.

4.3. To ensure the safety of testing personnel and equipment

Because the task is sent from a remote and operates the electrical energy metering device without personnel directly operating the metering equipment, it significantly reduces the danger to personnel in the detection test to protect their personnel safety. And it can monitor the status of the equipment through real-time data reporting, timely processing of the equipment over the limit, and other functions to protect the safety of personnel and equipment.

4.4. Guarantee the scientific and accurate testing data

The standard test result data is extracted directly from various electrical energy metering equipment and transmitted to the information system through the channel. Compared with the previous practice of generating reports from electrical energy metering equipment and then manually entering data to upload to the information system, the error rate caused by manual entry is reduced, thus guaranteeing the scientificity and accuracy of the testing data.

5. Conclusion

The study of communication protocols for energy metering equipment provides solutions for solving data siloing and intelligent equipment solutions. It also provides the basis for the analysis of communication protocols for existing equipment and application and the development of standard specification communication protocols for subsequent new equipment. Thus, the laboratory's automation, wisdom, and intelligence ensure the safety of laboratory testing personnel and equipment. Improve the scientificity, accuracy, and traceability of testing work.

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