Research on the Design of Automatic Testing Software for Modular Terminal Full Performance

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Abstract. Design the terminal full-performance automatic detection system software to realize the functional logic test of the actual table and the virtual table. The detection system is aimed at the detection of collection terminals. The system software is compatible with multiple protocols and supports system expansion. The automatic detection system adopts a multi-layer technical system design, through the service bus to realize the collaborative work of the components of the system, and realize the integration of all levels. The control terminal is connected with the collection terminal under test to simulate the communication situation. The inspection software supports business process testing, logic validity testing, performance limit testing and equipment compatibility testing. The designed automatic detection system software has the characteristics of low coupling, high flexibility, high scalability, and high reliability.

Keywords: Automated testing, system software, logic testing.

1. Introduction

The terminal full-performance automatic testing software can simulate the actual operating environment of the site to realize the functional logic test of the modular terminal and the existing inventory collection terminal with the actual meter and the virtual meter in various operating scenarios, and automatically determine the test results. If it is unqualified, the reason for the unqualified will be output. Automated detection software can reduce the possibility of problems with the collection terminal at the operating site, improve the functional reliability of the collection terminal and the detection rate of data security performance defects, and improve the technical capabilities in the full performance detection test of the collection terminal. On the basis of supporting the functional test part of the terminal full performance test, the terminal full performance automatic detection software can be compatible with the matching between the terminal and the on-site operating equipment, and further improve the consistency level and detection efficiency of the detection results. The design and development of the automated detection software system provides strong technical support for the construction of the full performance detection capability of the modular collection terminal.
2. Detection system design architecture
The terminal full performance automatic detection system is mainly for the detection of the collection terminal, so the system software is compatible with multiple protocols such as Q/GDW1376.1, Q/GDW1376.2, Q/GDW1376.3, and DL/T698.45. The virtual meter software is compatible with multiple protocols such as DL/T645, DL/T698.45, and CJ/T188, while retaining the scalability of the system to facilitate the expansion of other protocols or functions. The system verification function is mainly divided into basic function test, business process test, logic validity test, and supports the test of collection terminal performance, such as performance limit test and equipment compatibility test.

The automatic detection system can be connected to hardware interfaces such as power source, standard meter, and remote control board, as well as software interfaces such as remote database and encryption machine. The detection system includes functions such as common data upload, data export, certificate printing and data backup. The overall architecture diagram of the terminal full-performance automatic detection system is shown in Figure 1.

![Figure 1. The overall architecture diagram of the terminal full performance automatic detection system.](image-url)
business presentation layer, business process layer, service layer, component layer and resource layer. Through the service bus, the detection system realizes the collaborative work of the various components of the system and realizes the integration of all levels to meet the management business needs of different functional levels, and provide the business personnel with a technologically advanced work platform and flexible business structure capabilities.

The control terminal is connected to the collection terminal under test through the RJ45/RS232/RS485 converter, and the virtual meter is connected to the collection terminal under test through the RS485 converter, carrier communication converter, and M-BUS converter to simulate three forms of communication. The tester configures the data items and specific parameters of the virtual table. After the computer and the terminal to be tested are connected through a certain communication method, the verification program and tasks are issued through the verification software to test the terminal to be tested. When the terminal to be tested collects the virtual table data, it will respond to the verification software, and the software will analyze the message output result, and if it fails, it will further output the reason.

3. Testing system software design and development

The terminal full performance automatic detection system software is divided into two major modules, business function and system function, each module contains several sub-function modules.

As the core of the testing software, business functions can effectively improve the testing capabilities of the collection terminal's functionality, including basic function testing, business process testing, logical validity testing, performance limit testing, and equipment compatibility testing. System functions mainly include basic functions such as file entry, program management, and supporting functions such as logs and permissions.

The detection software can support terminal function verification of DL/T698.45 and Q/GDW376.1 two communication protocols. Check that the centralized meter reading terminal supports 645 and 698 two communication protocol functional requirements, mainly including concentrator and collector functional detection, data collection, management and storage, parameter setting query, event recording, local function, data transmission, terminal maintenance, etc. Aspect testing.

The testing process is flexible and configurable, you can test all the testing items, or you can select several key items to test, support testing items to be saved as a testing plan, and can be loaded again to facilitate subsequent testing.

The electricity consumption information collection system can detect the collection terminal alone, or it can be combined with an electric energy meter or a virtual meter to detect the terminal. The schematic diagram of the information acquisition system is shown in Figure 2.

![Figure 2. Schematic diagram of electricity consumption information collection system.](image-url)
The detection software supports business process testing, including data collection and supplementary copying, network access request processing and networking, active event reporting and reading, interface data interaction, concurrent meter reading, module ID management, station relationship identification, phase identification, and active power outage reporting. And effectiveness analysis, communication performance testing, etc. The software supports 3 kinds of logic validity tests, namely normal logic test, reverse logic test and asynchronous fault tolerance test. The software supports performance limit testing, that is, various performance indicators of the test terminal are sent through data packets.

4. Software communication design and development of detection system

The detection software supports 3 types of equipment compatibility tests, namely terminal-module compatibility test, terminal-electric meter compatibility test and terminal-master station compatibility test. When the terminal-master station compatible test collection terminal communicates with the background server, the link user data of the transmission frame needs to meet the frame format of the DL/T698.45 and Q/GDW376.1 communication protocol used, as shown in Table 1 and Table 2.

**Table 1. DL/T698.45 communication protocol frame format table.**

| Number | Description                  | Remarks                              |
|--------|------------------------------|--------------------------------------|
| 1      | Start character(68H)        |                                      |
| 2      | Length field L              |                                      |
| 3      | Control domain C            | Frame header                         |
| 4      | Address domain A            |                                      |
| 5      | Header check HCS            |                                      |
| 6      | Link user data              | Link user data (application layer)   |
| 7      | Frame check FCS             | End of frame                         |
| 8      | End character(16H)          |                                      |

**Table 2. Q/GDW376.1 communication protocol frame format table.**

| Number | Description                  | Remarks                              |
|--------|------------------------------|--------------------------------------|
| 1      | Start character(68H)        |                                      |
| 2      | Length field L              |                                      |
| 3      | Length field L              |                                      |
| 4      | Start character(68H)        |                                      |
| 5      | Control domain C            |                                      |
| 6      | Address domain A            |                                      |
| 7      | Link user data              | Link user data (application layer)   |
| 8      | Checksum CS                 |                                      |
| 9      | End character(16H)          |                                      |

Before parsing the message, the detection software verifies the frame header, frame end, and key, and data frames that fail the verification are directly discarded. Each uplink data or downlink command will receive a corresponding response frame. If the response frame corresponding to this is not obtained, the command will be sent again every 1s, a total of 6 times. If there is still no response, the command will be sent again when communicating again. In the protocol, the corresponding model can be generated based on the link user data to analyze the data field content.

The terminal's full-performance automatic testing items are divided into 3 levels. The first level is the detection of "physical channels". Check whether each channel is unblocked, whether the pre-connection is established, and ensure that the pre-connection channel is active. The second level is to detect the frame to ensure that the format of the frame meets the requirements. The third level is to detect
application layer data. The application layer protocol data unit data is parsed into corresponding instructions according to the rules to see if the collection terminal responds.

The detection software is designed for the 2nd and 3rd levels, which are designed for electric energy objects, maximum demand objects, variable objects, event objects, parameter variable objects, and freezing objects. The software tests show that Determine whether the acquisition terminal complies with DL/T698.45 or Q/GDW376.1 protocol communication by showing success or failure.

5. Software interface definition design of detection system

The interface design principles of the detection system meet the requirements of sharing, security, scalability, compatibility and uniformity, and uniform interface specifications for similar systems. The system interface methods include: SOAP (WebService) or Socket communication, etc. The data communication adopts the XML standard language format, and the transmission data is required to be encrypted. Among them, the communication with the measurement production management platform can adopt three interface modes: WebService, WebService plus intermediate library and intermediate library according to the type of business. Socket communication can be used inside the lower control system.

The detection system interface adopts three interface modes: WebService, WebService+ intermediate library and intermediate library. Real-time interactive information with a small amount of data is transmitted through the WebService interface, and real-time interactive information with a large amount of data is transmitted through the WebService+ intermediate library interface. Large timing interaction information is transmitted using the interface of the intermediate library. Interface interaction information is recorded in the intermediate library log table. The interaction flow chart of the WebService+ intermediate library interface, and the interaction flow chart of the intermediate library interface are shown in Figure 3 and Figure 4 respectively.

![Intermediate library interface interaction flowchart](image1)

**Figure 3.** WebService+Intermediate library interface interaction flowchart.

The WebService+ intermediate library mode is used for scenarios with real-time interaction and large data volume. The main process includes: (1) The initiator calls the log number acquisition function (GetLogID) to obtain the storage log number, and calls the storage interface (SaveLog) to write the log to the intermediate library log table. (2) The initiator stores the required data in the intermediate database table. (3) The initiator calls the interface to send data to the receiver. (4) After receiving the data, the receiver calls the log number acquisition function (GetLogID) to obtain the storage log number, and calls the storage interface (SaveLog) to write the log to the intermediate library log table. (5) The receiver obtains data from the intermediate library and performs business processing; (6) After the business processing is completed, the receiver calls the log number acquisition function (GetLogID) to obtain the storage log number, and calls the update log interface (UpdateLog) to update the log to the middle The library log table. (7) The receiver returns the result to the initiator. (8) After receiving the feedback result, the sender calls the log number obtaining function (GetLogID) to obtain the storage log number, and calls the update log interface (UpdateLog) to write the log to the intermediate library log table.
The intermediate library mode is mainly used in scenarios where a large amount of data is exchanged and timed. The main process includes: (1) The initiator calls the log number acquisition function (GetLogID) to obtain the storage log number, and calls the storage interface (SaveLog) to write the log to the intermediate library log table. (2) The initiator stores the required data in the intermediate database table. (3) The receiver obtains data from the intermediate library and performs business processing. (4) The receiver calls the log number obtaining function (GetLogID) to obtain the storage log number, and calls the storage interface (SaveLog) to write the log to the intermediate library log table.

6. Conclusion
The terminal full performance automatic detection system improves the data coordination ability of the system through service integration application logic, effectively reduces the data access load, and at the same time improves the system expansion ability through load balancing. The software adopts technical means such as parallelism at all levels to ensure the high reliability of the system. At the same time, a variety of emergency safeguard measures are planned at the application level to avoid disasters and ensure the stable operation of the software system. Strong expansion capabilities are planned and designed at the device control level, data access level and application level. Through the use of message middleware technology, the system has high flexibility in network communication and deployment. Through the design of the service interface, the detection software enables the subsystems to be coupled only at the interface level, which completely shields the internal associations of the subsystems, and minimizes the impact of changes within each subsystem on other subsystems.

The design of inspection software always adheres to the idea of service-oriented and hierarchical separation, and implements the system's principles of high reliability, high scalability, high flexibility and low coupling.

Acknowledgments
This research was financially supported by the Science and Technology Project of State Grid Corporation Headquarters(5600-201955457A-0-0-00).

References
[1] Zhai Xiaohui, Liu Hongguo. Design and realization of automatic assembly line verification system for intelligent electric energy meters [J]. Shandong Electric Power Technology, 2014, 41(6): 36-38.
[2] Peng Chuning, Luo Ranran, Wang Xiaodong. A new generation of smart energy meters supports ubiquitous power Internet of Things Technical research [J]. Electrical Measurement and Instrumentation, 2019, 56(15): 137-142.
[3] Dong Lijun. Design and technical research of automatic verification assembly line verification system for electric energy metering device [D]. Beijing: North China Electric Power University, 2017.
[4] Wang Libin, Wang Hongying, Zhang Chao. Research on the best maintenance frequency of automatic verification assembly line equipment for electric energy meters [J]. Electrical Measurement and Instrumentation, 2017, 54(8): 89-92.
[5] Depuru S S, Wang L, Devabhaktuni V K, et al. Smart meters for powergrid: Challenges, issues, advantages and status [J]. Renewable & Sustainable Energy Reviews, 2011, 15(6): 2736-2742.
[6] Q. Sun et al., A Comprehensive Review of Smart Energy Meters in Intelligent Energy Networks [J]. IEEE Internet of Things Journal, 2016, 3(4): 464-479.
[7] Wang Y, Chen Q, Hong T, et al. Review of Smart Meter Data Analytics: Applications, Methodologies, and Challenges [J]. IEEE Transactions on Smart Grid, 2018: 1-1.
[8] Alahakoon D, Yu X. Smart Electricity Meter Data Intelligence for Future Energy Systems: A Survey [J]. IEEE Transactions on Industrial Informatics, 2016, 12(1): 425-436.