Integrated Smart Warning Testing Based on Testing Platform of Dispatching Automation System

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ABSTRACT

With the popularization and application of power dispatching automation system in power grid, the integrated smart warning (ISW) has been widely used. A hidden hazard or problem in software may cause the dispatcher and operator to grasp inaccurate operation of power grid, which will affect the security of power grid operation in a wide range. The ISW software is tested and evaluated based on testing platform of dispatching automation system in this paper. By simulating power grid operation under fault conditions, the simulated primary and secondary steady-state signals are sent to ISW software. At the same time, WAMS and RELAY mocks are constructed to generate fault report, and the analysis results are also sent to ISW by means of message. It not only simplifies the testing environment, but also meets the requirements of ISW function testing. Finally, the testing results are analyzed, and a comprehensive quality index is given to evaluate the software quality. It will improve dispatcher ability to overall aware the power grid states and to handle emergency of equipment faults.

Keywords: Dispatching Automation System, Integrated Smart Warning, Testing Platform, Power Testing Case, Software Quality.

INTRODUCTION

With the widespread application of strong & smart grid dispatching supporting system at provincial and regional dispatching centers, the hidden troubles and problems in power system will affect its safe operation in a wide range [1]. The ISW can give warning when
power grid fault occurs, and analyze the fault information to accurately locate the fault. Software quality of ISW directly influences the security and stability of power grid operation, which requires high software quality [2-4]. Based on the testing platform of dispatching automation system, the ISW system is tested and the software quality is evaluated. Testing defects of software are fed back to the development process to achieve flexible iterative development and to improve software reliability.

TESTING PLATFORM FRAMEWORK

The software testing scheme of ISW is shown as Figure 1. The testing platform can be divided into four layers, including power system simulation layer, data simulation layer, dispatching automation system layer, and testing control layer [5-7]. The power system simulation layer is used to simulate the actual operating conditions of power grid to build a testing data environment. The data simulation layer is responsible for connecting the simulation layer and the dispatching automation system layer, and the simulation data of power grid is processed and sent to dispatching automation system via the standard protocol. The testing control layer is responsible for starting the testing, loading cases, monitoring the testing process, and evaluating dispatching automation system.

![Figure 1. Testing platform framework of ISW.](image)

TESTING AND EVALUATION OF ISW SOFTWARE

Effect Factors of the of ISW Result

The influencing factors of ISW include: the operation status of power system equipment, alarm and fault information, such as active power, reactive power, voltage, current, and switch position, protector action, abnormal and warning signals, substation fire alarm, and perimeter security information.
Required Data for ISW Function

The ISW integrates the fault analysis information in power system, as shown in Figure 2. It contains fault analysis information based on steady state information and SOE signals, dynamic fault analysis information of WAMS module, fault record of RELAY, and fault analysis results. The fault analysis information based on steady state information and SOE signals is the basis data information of ISW, and it is easy to build the simulation environment for steady-state monitoring data using the testing platform. However, it needs electromechanical and electromagnetic transient simulation for WAMS and RELAY module, and the data preparation is complex and the simulation validity is difficult to guarantee.

![Figure 2. Required data for ISW function.](image)

From the point of ISW software testing, ISW needs the analysis results of WAMS and RELAY but ignore its internal analysis and calculation. Therefore, we construct WAMS mock and RELAY mock to replace the application modules to improve the reliability and efficiency of testing. The mocks are responsible for sending the simulated fault analysis results directly to ISW.

**Testing Flow**

The main testing flow of ISW software is shown in Figure 3, and the simulation data is from three aspects. First of all, we can obtain data information through the power grid steady-state monitoring module, such as case limit exceeding, power flow limit exceeding, voltage off-normal, and SOE information. Secondly, fault report of short-circuit current information can be obtained directly from WAMS mock, such as fault equipment, short-circuit type, short-circuit current amplitude, cutoff capacity, etc. Then, fault recorder data and on-line secondary equipment working condition information is output from RELAY mock, including action information, abnormal information, and channel abnormality information of protection and control device. We can integrate these three data information to form a total fault report through the information fusion technology and ISW software identify, position and alarm the fault through the analysis of fault report.
Testing Case Generating Method

There are two ways to generate ISW testing cases, using extracting data from actual fault information or using customized simulation tools.

A. Using extracting data from actual fault information

The historical data management module regularly collects the data of real-time database and application database, and performs comprehensive data processing such as statistics, accumulation and integration.

Firstly, we collect the historical scenarios and data, including operation condition, status, analog, SOE data, alarms, planned values, forecasting data, event reports, equipment operation records, fault record, and so on. Secondly, the testing case can be obtained by automatically extracting the relevant information of certain fault event. And then, the testing case is verified in simulation system, including steady-state simulation and secondary system simulation, to ensure its accuracy. Finally, the testing case base is built.

B. Using customized simulation tools

We can generate an ISW case using the case management tool of testing platform. A single power grid fault case can be customized, and comprehensive case is to combine several single cases. The testing case information can be manually set in case management tool, such as case type, measuring point, value, execution timing, SOE timing, data setting type, offset, etc. The case type contains mode setting, signal generation, remote signal settings and telemetry settings. The measuring point is set by searcher. And the data setting type includes blockade, negation and offset. We can generate testing case by setting fault total signal, switch action, protection signal and other information.
Comprehensive Evaluation of Software Quality

The internal quality assessment of ISW software estimate uses analytic hierarchy process; the external quality assessment uses fuzzy comprehensive evaluation method, and the comprehensive evaluation make normalization processing for the internal and external quality indicators to form a final quality index [8, 9]. A higher requirement level of software quality is to make customers using happily. When assessing software quality models, software quality with excellent applicability will get some extra scores. Quality indicators of the internal attributes view 1.0 as the highest value, and it may obtain 1.0 point in case of full compliance with standards and specifications. Quality indicators of the external attributes get a score set {1.2, 1.0, 0.8, 0.6, 0.4, 0.2} that corresponds to {excellent, very good, better, common, worse, very bad}. The final software quality indicator can be obtained after determining weights of internal and external quality.

CONCLUSION

A functional testing method of ISW software is proposed based on testing platform of dispatching automation system, and the software quality is evaluated. The steady state monitoring data is obtained through the power grid simulation of testing platform, and the fault reports are generated through the simulation mock and the actual system information. This method need not deploy WAMS and RELAY modules. It is more convenient to build testing environment and make the testing more practical.

REFERENCES