Design and Application of a Test System for Ship Platform

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Abstract. Aiming at the problems of single function, poor integration and low expansion performance of the traditional test and test tools for ship platforms, an integrated test and test system based on an integrated and distributed architecture is designed and studied. Through the index system construction, system (equipment) test evaluation, data modeling and simulation, we develop an integrated simulation test platform, support the software and hardware functional test and test of ship platform system equipment, support the generation of test data, and comprehensive evaluation of equipment capabilities.

1. Overview
Aiming at the problems of difficult physical injection, high risk, long cycle, and high cost of test physical verification tests, in accordance with the general, modular, serialized, intelligent, and integrated design principles, a ship platform equipment test index system is established based on big data, Cloud computing technology develops simulation test and test platforms. Based on breakthroughs in key technologies such as virtual instrument hardware, test interfaces, and software platform generalization, it achieves a universal solution for large-scale complex equipment test, test, and evaluation [1].

2. Overall System Design

2.1. System Architecture
Traditional equipment simulation test systems generally use stand-alone test equipment. With the development of technology, the Internet of Things, edge computing, big data and other technologies have gradually matured, but they are still rarely used on large and complex equipment. The test and test simulation platform designed in this article is implemented on the basis of cloud computing. It combines cloud computing and test platforms to identify simulation test requirements around equipment tests, and establishes tests based on theoretical research, technology development, and engineering applications. Platform architecture to build a complete test system.

2.2. Feature Design

2.2.1. Construction of Test Index System. At present, domestic test indicators are mainly focused on fault detection rate, fault isolation rate and false alarm rate. In fact, the testability indicators are not limited to these. The foreign research on system-level testability indicators also includes: undetected faults, fault fuzzy sets, redundant tests, hidden faults, false fault sets, feedback loop identification, test
sequences, Diagnostic tree, etc. Based on the requirements of domestic testability evaluation and the requirements of relevant national military standards, a comprehensive test index for equipment is constructed in the system design, and a single-equipped, model-type equipment test evaluation index system is established [2].

2.2.2. System (Equipment) Trial Test Evaluation. Component / component level. Aiming at the problems of fuzzy performance evolution rules of key components / components of the equipment and low accuracy of test and evaluation, combined with the installation and experimental data of key components of each system, research on the key component performance influencing factors and feature parameter extraction methods to build multi-season and multi-region Scale, multi-level performance characteristic analysis model; extract the influencing factors of key component health status, construct multi-parameter evaluation model of decay, failure, and health status, study the evolution law of key component full life cycle safety performance; study the multi-dimensional distribution characteristic mechanism of key component failure The key component performance and fault inversion process under low-dimensional parameters are used to build a high-fidelity low-dimensional evaluation model and a tactical performance characteristic parameter database. Establish a key component performance evaluation model library and form a critical component test evaluation system to improve the accuracy, timeliness, and robustness of analysis and evaluation.

Device / sub-system level. According to the technical index requirements of each sub-system of the equipment, research key technologies such as sub-system test and evaluation system, operating state perception evaluation, sub-system in system simulation and simulation environment test evaluation, etc., and analyse the equipment operation of the equipment sub-system's static parameters coupled with the operating technology status Mechanism, establish a sub-system state perception model that integrates key component data and operating technology status data, and a tactical performance evaluation model that takes into account factors such as equipment type and test assessment conditions, and build a multi-dimensional comprehensive test and evaluation database for each sub-system of the equipment. The performance of each sub-system during the entire process is accurately evaluated.

Platform / system level. Aiming at the test development and evaluation of the entire system of the equipment, research on key technologies such as multi-dimensional analysis and evaluation of equipment technical conditions, precise control of test parameters, and coordinated testing of equipment sub-systems, establish a correlation model between the test environment, equipment performance, and evaluation tasks, and build equipment systems Test and evaluation database, development of equipment system-level test evaluation system, accurate generation and control of test parameters, coordinated test management of equipment sub-systems based on optimal scheduling technology, establishment of a system-level equipment test, verification, and evaluation application platform to form a comprehensive equipment test and test system Process evaluation system.

2.3. Software Design
Equipment test and test system software consists of server software and client software to form a distributed architecture. The client software is responsible for running and interacting with the communication board. The integrated service platform software is responsible for implementing test design and test execution scheduling. The integrated service platform server and multiple Clients can form test systems of different scale levels [3] to ensure that test requirements of different scales are met.

The software architecture is divided into three layers, namely the communication service layer, the application service layer and the application layer. Through these three layers, the software is modularized and modularized to ensure that it can adapt to rapidly changing test requirements.
The communication service layer is used to encapsulate the program programming interface on the basis of the driver layer to shield different communication programming interfaces of different hardware devices. The communication service layer includes CAN communication, RS232 communication, RS422 communication, RS485 communication, etc. The layer can ensure that the upper-layer application software can implement the call uniformly.

The application service layer lays the foundation for the main application of the test platform through a series of application components, including test solutions, test projects, simulation model drawing, channel management, protocol management, peripheral devices, monitoring design, monitoring runtime, I/O center, Metadata server, script parsing, client management, timing processing, multi-threaded service, data object encoding/decoding, etc.

The application layer is the main application part of the test system, including test design software, test execution service software, test execution client process and data monitoring software, equipment resource management software, and some tool assistance software.

3. System Composition
The test platform uses a distributed architecture design. The whole system consists of power plant simulation test subsystem, propulsion simulation test subsystem, ship bridge simulation test subsystem, safety management simulation test subsystem, management decision simulation test subsystem, integrated test tool platform, and integrated test service platform.
3.1. Integrated Test Tool Platform
The integrated test tool platform is a set of tools, including dedicated measurement instruments: network testers, bus testers, incentive cabinets, multimeters, etc.; test simulators for ship sub-systems, software quality evaluation tools, embedded test tools. These tools run on the test software platform and test equipment, and are combined according to the test needs of each subsystem.

3.2. Integrated Test Service Platform
The integrated test service platform consists of hardware infrastructure and big data software, where the infrastructure includes comprehensive management computers, server clusters, etc.; big data software includes data access, cleaning, processing, storage, real-time and offline computing, and distributed message bus, Structured and unstructured data.

3.3. Each Simulation Test Subsystem
Each simulation test subsystem tests the ship's sub-systems. It consists of an integrated test tool and a remote control unit. Functionally, this subsystem can simulate all the functions of each sub-system and provide signal-level simulation. Function, can also collect the operating data of each sub-system under different test scenarios.

4. Design of Test Cases

4.1. Test Case Design
The first core task of testing is to generate and execute software test cases. The main purpose is to detect and eliminate errors that occur before the system software is put into operation, and to provide a high-quality and reliable product. The test case is a description of all possible events, results, and environments during the testing of the software. For specific and combined functions, write test plans and develop documents. The use case selection must be both general and special, and comprehensive consideration of various occurrences or occurrences.

Generating and executing software test cases is the core task of software testing. The basic purpose of test case design is to determine a set of test data that is most likely to find a certain error or a certain type of error in order to test a certain function of the system. According to the state of testing the equipment software, the design method of software test cases [4] can adopt the equivalent division method, boundary value analysis method, and error estimation method.

4.2. Test Data Modeling
The data input and output interaction between each test subsystem and the device under test in the device is as follows:

1. The test data can be divided into event-driven and cycle-timed driving;
2. The output corresponding to the test data input can be divided into two types: output with and without output;
3. Multiple test data the data can be divided into two types: the existence of a logical timing relationship and the absence of a logical timing relationship.

The test and test platform modeling adopts the abstract model method. The basic data types are used to define the abstract data types. The operations on the basic data types are used to define the operations of the abstract data types. The XML format is used to define and extend the types. The structural specifications suitable for the system are designed. Design a description language to form a hierarchical model specification expression ability.

A simulation model usually consists of model description, scheduling information, test data, result evaluation, and model cross-linking. In order to realize the management, editing, development, and debugging of simulation model code, an interface for code editing of the simulation model is developed, and the code debugging function is provided.
In the simulation model management, it integrates the model framework function, associates the simulation model in the designer, provides parameterized scripts for the model, and calls the analysis function to automatically generate the code of the simulation model.

4.3. Test Data Generation
Use the platform simulator to generate system test data. The specific steps are as follows:
(1) Factorize the data types and logical timing of test cases;
(2) Describe these elements to get a data-driven model, with multiple data combinations as test cases;
(3) After the test case is built, it is converted into a driver file according to a certain protocol. When the test is started, the integrated management computer simulates these driving files to test the subsystem. After receiving the driving files, the simulated testing subsystem analyzes the instructions and identifies the execution instructions. The integrated test service platform coordinates the simulation test subsystems to drive the automatic execution of each step of the test case, so as to realize the automatic execution of the equipment test process in each scenario.

5. System Implementation
The platform test and test system is built based on Visual Studio with a human-computer interaction interface, and uses Visual C# [5] language to develop and package the model library. The system test software has functions such as function test, performance test, interface test, stability test, pressure test, and automatic evaluation of test results. It has a high degree of automation and good expansion ability. In terms of system evaluation, after the test system is used, the administrator can perform evaluation through simulation data. The fault variable program for evaluation has been set in the simulation software. There are two ways to start and use the fault variable program. After the fault variable is activated, the cause of the fault can be analyzed according to the parameter changes and phenomena of all operating equipment in the cabin, and the evaluation result is finally given.

The fault editor main interface is shown in Figure 3.

![Fault editor main interface](image)

Figure 3. Fault editor main interface

6. Summary
The test system for ship platforms has the features of complete functions, good versatility, flexibility and scalability, and support for real-time testing. The use of this system has the following advantages and innovations:
(1) Analysis of evolution law of multi-scenario operation performance
Aiming at the characteristics of various application scenarios such as equipment testing, testing, complex environment, various space-time dimensions, difficult to evaluate technical status, and complex and changeable evolution rules, based on test data and data during equipment development,
establish key equipment features at multiple time and space scales. Recognition model, breaking through the problems of multi-source coupling of key component parameter features, fuzzy security features, and insufficient systemicity, to achieve system-level equipment function, performance feature construction, and state estimation; based on key equipment feature recognition models, combined with component mechanism models, experts knowledge and big data mining methods, decoupling and reconstruction of key indicators that characterize equipment test identification parameters, establish equipment system-level test feature databases, and realize theoretical application innovation of equipment's full test cycle performance evolution law analysis theory.

(2) Equipment test capability evaluation technology

In response to the need for auxiliary decision-making for new equipment test conclusions, from the dimensions of component models, equipment characteristics, and system application, an equipment test and test capability evaluation system was developed, and large-scale test operation data was used to analyze and extract multiple types of equipment data and feature fusion. Build feature parameter sets and parameter mapping sets for specific experimental tasks based on big data to form mapping relationships between various feature parameters and corresponding equipment states; based on data mining, deep learning, experimental testing, and other methods, comprehensively consider the relationship between multiple factors Coupling effect, put forward a multi-dimensional equipment test capability evaluation system such as equipment, sub-system, system and system level, reveal the characteristics and evolution mechanism of equipment in various scenarios, provide a theoretical basis for accurate evaluation of equipment, and implement big data-based Equipment test capability evaluation technology integration and innovation.

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