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A Virtual Training System of the Missile Test Launch and Control System

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***Abstract*—Aiming at the teaching requirement of the missile test launch and control system, through analyzing the working principle and full task training process of the missile test launch and control system, a virtual training simulation system architecture was constructed based on HLA, and the realization method of distributed management function of simulation data was realized by using embedded database management technology. In practice, it was proved that the virtual training simulation system could effectively realize the test launch and control process of the missile, meet the needs of teaching and training, and had great practical significance.**

***Keywords*—virtual training system; test launch control system; missile; HLA**

I. INTRODUCTION

With the continuous progress of system modeling and simulation technology, simulation application in the field of weapon system training had a very broad research prospects and expansion space [1]. In order to meet the need of improving post competencies, how to build a full task virtual training simulation system was one of the key factors to improve the level of military equipment training [2]. In this paper, aiming at the teaching requirement of the test launch and control system of the missile, through analyzing the working principle and full task training process of the missile test launch and control system, a virtual training simulation system architecture was constructed based on HLA, and the realization method of distributed management function of simulation data was realized by using embedded database management technology. By the teaching practice, it was proved that the virtual training simulation system could effectively realize the operational application procedure of the missile, and meet the needs of teaching and training for the test launch and control system.

II. ANALYSIS OF TECHNICAL CHARACTERISTICS OF THE TEST LAUNCH CONTROL SYSTEM AND REQUIREMENTS OF VISUAL TRAINING SIMULATION

The test launch control system of the missile was one of the core equipment related to the missile weapon system's continuous operational capability, which mainly consisted of central console, test console, fire calculation console, command and control information console, inertial navigation console, centralized launch console, missile (or missile simulator) and others. The system was complex, and composed of a series of hardware such as multiple operating stations, multiple chassis, control panel, function board, cable and so on. The information exchange among different operating stations was carried out based on bus, so as to realize the functions of missile test launch and control. From the view of technology, the test launch and control system adopted a multi-computer TT&C network system, involving many equipment cooperative operators, complex information exchange process and high requirements for collaboration.

Considering the technical characteristics of the above-mentioned equipment and the fully difficulties of using the actual equipment for training and teaching, it was of great practical significance to develop the simulation application of the above-mentioned equipment for improving the level of equipment training. From the technical point of view, a virtual simulation training platform was constructed by the composition of actual equipment system, and the application of the distributed simulation technology, which was conducive to ensuring the interaction, collaboration and completeness of virtual simulation training.

III. DESIGN AND IMPLEMENTATION OF A VIRTUAL TRAINING SIMULATION PLATFORM FOR THE TEST LAUNCH AND CONTROL SYSTEM

A. Analysis of Function and Process for the Virtual Training and Simulation Platform

Starting from the basic training requirements of the missile test launch control system, basic training operation with equipment emergency disposal and accident rehearsal was combined for the training needs of deep-seated post competence in the design of the virtual training simulation Platform. The functions of virtual simulation training platform of the test launch and control were designed as follows: (1) system self-test function; (2) function of work process control (including fire preparation, fire ready and fire stages); (3) function of subsystem test; (4) function of integrated test; (4) function of launch; (5) function of emergency management; (6) function of troubleshooting and analysis.

In the process of virtual simulation training, different training contents could be set up through training courses and the emphasis of training was also different, involving the basic operation level, troubleshooting training level, emergency management training level of equipment and others. The main training courses was consist of system self-test training, troubleshooting training of system self-test, subsystem test training, troubleshooting training of subsystem test, integrated test training, troubleshooting training of integrated test , launch

training, emergency management training of launching and so on. The full-task virtual training simulation process was divided into three stages: fire preparation, fire ready and fire. The specific full-task virtual simulation training process was shown in Figure I.

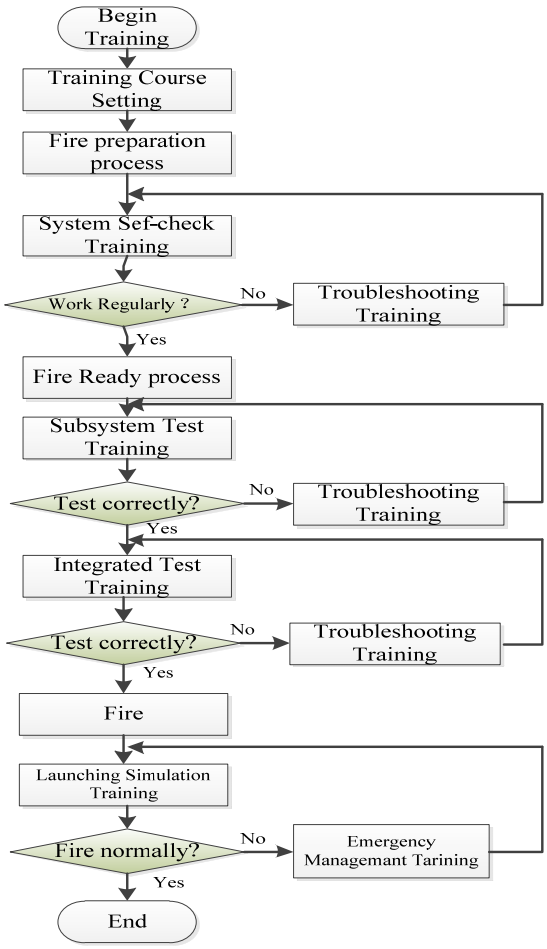

FIGURE I. FULL-TASK VIRTUAL SIMULATION TRAINING FLOW OF TEST-LAUNCH-CONTROL SYSTEM UNITS

B. *Design of Architecture of Virtual Simulation Training Platform*

In the development of a distributed interactive simulation system, many problems was often involved, such as more simulation nodes, frequent information exchange between simulation nodes, complex data cross-linking relationship, etc. The system integration of simulation application would consume a lot of time and energy for system developers. The architecture of simulation system was a key core issue. At present, the mainstream architecture of simulation system mainly was as follows: the advanced distributed simulation architecture based HLA/RTI [3], communication technology architecture based on TCP/IP protocol, communication technology architecture based on P2P point-to-point commutation mode and architecture of third-party toolkit based on TCP/IP protocol. The specific choice of architecture was constrained by many factors, such as fund, development cycle, system size and developer preferences and equality. However, no matter you chosen, the functional requirements of the simulation system should be to meet.

Considering the composition, technical characteristics and work process of the missile test launch and control system, a virtual simulation training platform for the system above-mentioned was designed in view of the technical advantages about the distributed simulation architecture HLA/RTI [4-5], which could realizes the function of cooperative training and process controlling for the missile test launch and control system through visual simulation training mode. The virtual training platform could be divided into two parts: simulation support platform and equipment simulation module. Simulation support platform was the operation basis for the whole visual training simulation system, which mainly included the design of federate member object class and federate member interaction class based on HLA [6]. Equipment simulation module was the core part of the simulation platform, and mainly used for the simulation construction of training members, such as central console, test console, fire calculation console, command and control information console, inertial navigation console, centralized fire control console, missile (or missile simulator) and others.

The virtual simulation training platform of the missile test launch and control system was mainly composed of central control simulator, test control simulator, fire calculation simulator, command and control information simulator, inertial guidance information simulator, centralized fire control simulator, missile simulator and others. It was composed of high-speed Ethernet for information interconnection. HLA/RTI was selected as the simulation support platform, and Federation design was carried out [7]. The Architecture of the visual simulation training platform system was shown in Figure II.

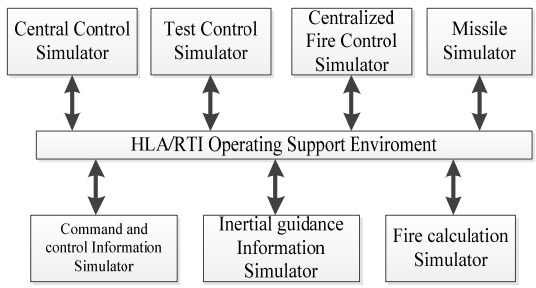

FIGURE II. ARCHITETURE OF VIRTUAL SIMULATION TRAINING PLAFORM

C. *Application of Embedded Simulation Database Management Technology*

Many federates were included in the virtual simulation training platform of the missile test launch and control system. Frequent information interaction and interoperability was applied in the process of the training simulation system. Real-time management and interaction of a series of simulation data should be used, such as test flow database, operation procedure database, test database, fault information database, fault troubleshooting case database, etc. Generally, large relational databases based on C/S architecture (such as SQL Server, Oracle, etc.) in most simulation training systems were used to manage simulation data, which also had some problems such as

high cost of hardware and software, complex configuration of system management, and huge database software[8-9]. In order to further improve the performance-price ratio of virtual simulation training platform, the embedded simulation database technology was applied in the design of the simulation data management system. The solution of embedded database based on Berkeley DB API was used, the database server was simplified from hardware and the underlying database reduced from software driver interface or third-party tool software dependency [10]. According to the requirement of virtual training simulation, the concrete simulation database structure was shown in Figure III. In the process of virtual training simulation platform practice, the simulation data management architecture was shown in Figure IV.

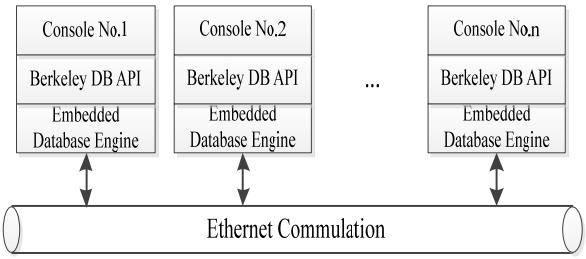

FIGURE III. SIMULATION DATABASE STRUCTURE BASED ON EMBEDDED DATABASE ARCHITETURE

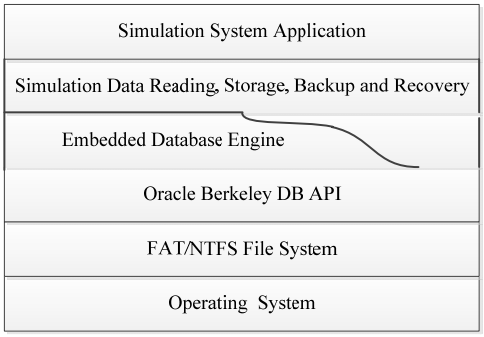

FIGURE IV. MANAGEMENT ARCHITECTURE OF SIMULATION DATA

There was essentially an application programming interface in the software Oracle Berkeley DB, which could be developed many program languages such as C/C++, Java, Perl and Python for the store and access of simulation data in the same process space as the main course. Considering that the system integration software was Visual Studio C++ 6.0, the C++ API of Oracle Berkeley DB should be used in the design of simulation data management system. Also an embedded database engine based on C++ API of Oracle Berkeley DB was developed.

The relationship between the embedded database engine and Oracle Berkeley DB subsystems, fault tolerant and exception handling interfaces and simulation systems was shown in Figure V. In addition to encapsulating Oracle Berkeley DB data management mechanism, database engine also provided a network support for simulation database according to the network communication infrastructure adopted by the simulation training system. The aggregation relationship between classes encapsulated by embedded database engine and Oracle Berkeley DB API class was shown in Figure 6. The whole product of embedded database engine was a set of dynamic link library files (*. dll) and header files (*. h). Application developers could access and store simulation data only by calling directly the interface functions in the header files [11].

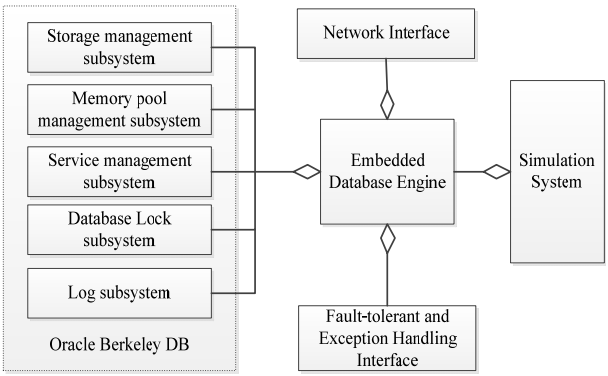

FIGURE V. ARCHITECTURE OF EMBEDDED DATABASE ENGINE

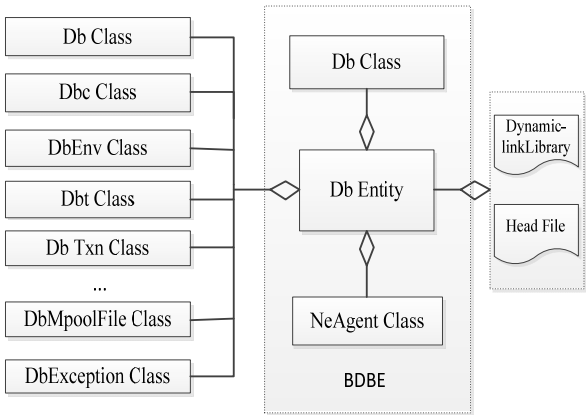

FIGURE VI. AGGREGATION RELATIONSHIP BETWEEN ENGINE PACKAGE CLASS AND ORACLE BERKELEY DB API CLASS

The simulation data management system based on the above-mentioned embedded database engine, such as test flow database, operation procedure database, test database, fault information database, fault troubleshooting case database, was mainly used for accessing, reading and storing simulation data of federates in the process of virtual simulation training, and importing/exporting corresponding database files (*.db) on the basis of training tasks. Reasonably, the corresponding *. DB file could be used directly for federate high-level applications.

D. *Implementation of the Training Simulation System*

The virtual training simulation system of a missile test launch control system is based on distributed real-time simulation technology. The hardware was built based on Tidal Company industrial computer IPC-610, simulation operation desktop and high-speed 1000M Ethernet [12]. Windows platform was used, and the Oracle Berkeley DB software to develop the simulation data management system of test flow database, operation procedure database, test database, fault information

database, fault troubleshooting case database. VC++ software was applied for system integration.

IV. SUMMARY

Promoted by computer, network communication and simulation technology, distributed interactive simulation technology had been widely used in combat simulation, simulation training and so on. In this paper, a virtual simulation training system for the missile test and launch control system was developed based on distributed interactive technology. The technical problems such as the architecture of virtual simulation training platform system based HLA and the development of embedded database engine were discussed in detail. The system was realized, which could effectively meet the needs of equipment teaching and training for post transition education reform, and had great practical significance.

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