Research of Electronic Countermeasure Simulation System Framework Based on HLA

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Abstract—With the promotion of the High Level Architecture (HLA) in recent years, the distributed simulation technology based on HLA is applied more and more widely in the military field, to meet their own specific needs, more and more military simulation systems are developed by HLA technology. Based on HLA thoughts, this paper studies the specific form of a kind of electronic countermeasure simulation system framework, and discusses the function and the key technology used of every module in the system, and gives a simple description of the overall simulation process of the system finally. Meanwhile, such studies also have some reference of the design and development of HLA-based simulation system on other areas.

Index Terms—HLA, Simulation System, Federation, Electronic Countermeasure, Structure

I. INTRODUCTION

With the development of science and technology, the information war has begun in human campaign. The future war has tended to the information war. And the electronic countermeasure has become the forerunner of the information war, which played an important role in changing the power comparison on both sides, deciding the fighting process and victory or defeat.

However, in modern war, the practical weapons take a lot of labor, resources, money and time in experiments and training. Moreover, it has become harder and harder to get actual data only depending on physical experiment and because of complexity and dependency on fighting environment of modern high-technical weapon system. As the same as the wide application on other domains, simulation technology is widely used, whose application has greatly boost the development of electronic countermeasure [1]. In summary, the application of the computer simulation technology on the design of electronic countermeasure system has certain necessities.

Nowadays, electronic countermeasure simulation system has developed for high fidelity of model, interconnection, expandability and reusability. Simulation platform has friendlier man-machine interface, stronger function, bigger scale and higher automation. HLA has been successfully applied to electronic countermeasure simulation system because of its reusability and flexibility.

The design idea of HLA gives great inspiration to the design and developing practice of the framework of electronic countermeasure simulation for us. The paper has a research on and proposes the framework of electronic countermeasure simulation system based on HLA, which is divided into each federal member and analyze the function of each module standing on the practical need of electronic countermeasure system, on the basis of HLA and the component development. It also has a research on key technology in the process of design and developing, which simply described the simulation flow at last. In a word, it has a certain reference value for the developing of similar simulation system.

II. THE DESIGN OF THE FRAMEWORK OF SIMULATION SYSTEM BASED ON HLA

The electronic countermeasure simulation system mainly realizes the simulation function of collaborative electronic reconnaissance, collaborative electronic attack and collaborative electronic defense. From above functions, the simulation system needs some modules to make collaborative simulation, namely distributed simulation. Based on the above analysis, the architecture framework of the system applies to distributed interactive simulation.

Distributed interactive simulation is the way that the system makes use of consonant structure, standard, protocol and database to form the synthetic and participable environment by LAN or WAN through interconnecting with simulation equipments everywhere. The key problem of distributed simulation is interoperation among lots of simulation modules (or subsystems). To solve this question, the system adopts the HLA of modeling and simulating. Universal and relatively independent interactive service program are supplied in HLA by running back-up environment to separate the realization of simulation function, operation management from the bottom communication, so that every part can be developed separately.

A. The Summary of HLA

HLA is the high level architecture of distributed interactive simulation, used for producing the common
technology framework in computer simulation system, which was first proposed by Department of Defense, USA (DOD) in modeling and simulating in 1995 to increase the rate of the running efficiency and cost by enhancing the interoperability of the simulation application and the reusability of the resources.

Flexibility is very important for simulation architecture, which need to have the ability of choosing different developing languages in different environments, at the same time with the interoperability and reusability between each component in simulation system. HLA brought in the basic thought object-oriented to design and develop simulation object model of SOM in different level and granularity, which deals with the function in the simulation system into the standard interface between every federation and outside for information interaction. Based on above, it builds the FOM to form the standard interface among federations [2], realizing the interoperability and reusability in high level of the simulation system. The hierarchical structure of the simulation based on HLA is illustrated in Figure 1.

Figure 1. The hierarchy of HLA-based simulation system

In Figure 1, federation is a distributed simulation system used to achieve a particular simulation purpose, which consists of a number of interaction federal membership. In the simulation system, the integrated control system of the information warfare is just a federal system, and each sub-module shall be a federation member, such as red simulator is just one.

In the HLA, the running time support structure (RTI) is introduced which, through the HLA Interface of the federal members, explicitly separates federate simulation application model, simulation support functions and data distribution from transmission services by means of FOM. Thus, in the case of large changes of the original system, the new simulation system and the original simulation system can still connect. A typical simulation based on the federal structure of HLA shown in Figure 2 [3].

In Figure 2, an open and distributed simulation system is together constituted by the Federation members and the Runtime Infrastructure RTI. In this architecture, each part module can be relatively independently developed and the latest technology in their respective fields can be furthest used to achieve the function of the system.

During the development of simulation system, support environment RTI and interface RTI will be encapsulated to help developers to focus on the realization of the function of all members of the Federation, thereby improving the efficiency of the entire system development.

B. The Basic Design Requirements of Simulation System

The following basic design requirements must be considered in order to better meet the interconnection, interoperability, interoperability requirements and function of the system in HLA-based electronic warfare simulation system [4]:

(1) Based on standard technology system in the field of distributed interactive simulation, the simulation system provides a standard interactive and control interface that can communicate with other simulation systems and have good scalability.

(2) During running exercise of electronic warfare system, the operator can command federal members of the various operations of system by the human-machine interface and the computer can generate the command process. So this can increase the flexibility of the system.

(3) Realize visual display of the process of electronic warfare, facilitate checking the model output for technical staff and master familiarly the process of electronic countermeasures for watching officer.

(4) In the system design process, you must take fully account of simulation system architecture, the norms and standards of model description, norms and standards for visualization, norms and standards of network communication and the development norms of federal.

C. Functional Description of Simulation System

HLA-based electronic warfare simulation system is a distributed simulation system which mainly researches simulation application in the comprehensive operational environment under the case of the offensive and defensive combat and goes to verification and validation of its performance and effectiveness. Main function of HLA-based electronic warfare simulation systems are following:
(1) Build more realistic electronic combat operations environment.

(2) Provide a friendly human-computer interaction function to easy to involve into simulation process for user and achieve the visual situation environment.

(3) Convenient and effective data management and model management.

(4) Provide analytical tools of the simulation results and be able to analyze the operational effectiveness of the electronic warfare simulation system.

D. Modular Division of Simulation Framework

HLA-based electronic warfare simulation system can be divided into two parts in the overall structure. The first part is the executable library of simulation and the second part is the user interface. Module partition of HLA-based Electronic Warfare Simulation System shown in Figure 3.

- **Director platform**: Its main function is to promote the operation of the simulation system and to initialize the simulation based on prior demonstration program and then to provide the underlying support model run on the prior arrangement, which mainly include the platform model, electromagnetic radiation and the sensor detection model, communication model and so on.

- **Integrated Control System of the Information warfare**: It mainly complete the simulation of operational command and control logic used to the typical process of the electronic warfare. The process includes coordinated electronic surveillance, coordinated electronic attack and coordinated electronic defense. When it completes the command and control simulation, the system calls two function module, electronic warfare command coordination module and reconnaissance module.

- **Database System**: In this simulation system, database is used to access various types of data and manage data. The underlying database stores all kinds of basic data, such as radar technical parameters. Simulation database save the simulation results and provide sample data. Dynamic exchange database store various temporary data generated during the system operating. Three-dimensional visual database is used to store the necessary information data of object entity during the system demonstrate. At the same time, the system also provides database management functions to manage and maintain the database and display and print the results data.

- **Model Base System**: It stores various models needed during the system operating. Model library structure is complicated and its types are more. So model base system is required having a very strong management capabilities. In this simulation system, model library mainly stores three types of model. Combat simulation model is generally described by tree and rules. System simulation models include continuous system simulation model and the continuous-discrete event hybrid systems simulation model. Calculation and evaluation model is generally described by the analytic expressions.

- **The platform simulator**: The simulation system generally has two types simulator of red and blue side, and each type has a total of six kinds of concrete platform simulator: warning device platform simulator, early warning helicopter platform simulator, electronic warfare aircraft simulator platform, attack aircraft simulator platform, carrier-based unmanned aerial vehicles and so on.

III. THE FUNCTION ANALYSIS OF THE FRAMEWORK

A. Executable Program Library of Simulation

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surface vessels platform simulator platform simulator. Each platform simulator mainly help information integrated control system with completing electronic warfare process.

(6) Three-dimensional visual system: It uses multimedia format to demonstrate for user the whole process of electronic warfare simulation which includes unified battlefield situation, the simulator reconnaissance work parameters, operational resources, operational command information, simulation plans and human-computer interaction and so on and then display the results. This process is mainly demonstrated by animation and graphically.

(7) Performance Evaluation System: In accordance with the requirements of the electronic warfare system operational effectiveness evaluation system, we should record the simulation data and then facilitate subsequent analysis. According to the simulation records data for statistical analysis, performance evaluation system calculates the effect of interference system and assesses equipment operational efficiency of electronic countermeasure systems.

B. User Interface

User interface for human computer interaction complete the program running and the analysis of simulation data. User can call the corresponding models, the model parameters, data, and simulation control parameters through the user interface. User can statistically analyse simulation results after repeatedly running using some of the simulation method in the simulation environment.

IV. KEY TECHNOLOGIES OF SIMULATION SYSTEM FRAMEWORK

A. Adoption of Advanced Design Approach and Simulation Concept

Based on the design thought of systems engineering is combined with software engineering, HLA high level architecture structures, distributed interactive simulation is adopted to design of simulation environment [6]. Thus the system has good simulation interoperability and reusability of resources, as well as good scalability.

B. Simulation Technology

Unified Modeling Language (UML) is a well-known object-oriented modeling method, which absorbed the advantages of other techniques in object-oriented modeling field, with serious description and good scalability. UML aims to describe arbitrary systems by means of object-oriented graphs [7].

In electronic countermeasure simulation system, we adopt use case diagram of UML to describe the system task and function, class diagram to describe system composition, and interaction diagrams to describe command and control relationship, all possible state (including scouted state, disturbed state, armed state, etc.) that system may experience in once job and various activities can be described with state diagram and activity graph. In a word, the use of UML modeling languages provides a modeling mechanism for the entire system development in the process of electronic countermeasure simulation design, and some vague origin ideas gradually described clearly and accurately, made the simulation model easy to establish, and can be directly converted into system design and achievement.

C. Construction of Database System

The construction of database is a complex but indispensable work. In the entire construction of simulation database system, guided by design ideas of the process iteration and step wise refinement, to construct the optimal database schema, plan and structured data objects in the database and their relationships. To make data efficiently store in the database system, and meet the demands of various applications of simulation system.

D. Description of the Confrontation Process

Electronic countermeasure is a three-dimensional confrontation, is a integrated countermeasure process of multiple reactance measures used, factors such as cooperative engagement, choice of confrontation strategic, resource allocation and implementation process have a direct effect on the confrontation. Thus, the description of electronic countermeasure is the important content of the electronic countermeasure simulation system, how to precisely describe constantly changing confrontation process is always a difficult problem of effectiveness simulation. In this system, actions in electronic countermeasure simulation process are merged and classified according to related entities, responding description template is made, which is applied in the simulation demo.

E. Design of Human-computer Interface

The system is developed in the integrated development environment of VC++6.0. The document/view application framework of VC++ is a significant feature of the application program developed in VC++. Under this frame, the generation, storage, management, analysis and utilization of data are all completed by document class, the view class complete the data display and human-computer interface interaction. The application of the frame in the simulation, not only achieved efficient simulation, but also provided human-machine interface with powerful function and convenient operation [8]. Through human-computer interaction interface, users can flexibly configure on-line control simulation of the simulation object, complicated analyze and processing the simulation data to determine the overall electronic countermeasures effect, but also can easily observe the complete simulation process of electronic countermeasure in various ways.

V. OVERALL SIMULATION PROCESS OF SYSTEM

A typical overall simulation process of HLA-based Electronic Warfare System includes three processes of the electronic reconnaissance, electronic attack and
defensive. Specific simulation process shown in Figure 4.

As can be seen from Figure 4, the system run a simulation process as following:

1. At simulation starting, simulation staff start director platform, initialize simulation scenario and select emulation mode. At the same time, the director platform sends the initialization information to the information warfare integrated control system.

2. According to information needed to initialize the simulation device.

3. Integrated control system of information reads pre-established operational plan (electronic reconnaissance, electronic attack or electronic defense), or the users develop operational plans.

4. According to operational plans, control commands should be sent the appropriate platform simulator.

5. Platform simulator executes the command and then returns the implementation results.

6. The integrated control system of information warfare sends the object entities information in platform simulator to three-dimensional visual system to display and then simulation end.

VI. CONCLUSION

HLA-based electronic warfare simulation system fully reflects the confrontation of systems, the system design of advanced electronic countermeasure of system warfare to meet the future needs of high-tech local wars. In this paper, the simulation system development platform based on HLA structure solves the integration problems between different simulation applications which satisfies requirements of the simulation system operability, reuse, strong real-time, scalability, and strong interaction. It is also worth mentioning that electronic warfare simulation system based on HLA/RTI thinking design increase the in-kind, semi-physical simulation as a federal member into federal simulation. So it is easy to develop early functional simulation of integrated electronic warfare and more easily meet the authenticity of the simulation. But for the development of a high confidence HLA-based simulation system, there are many issues to study, such as the coherence of temporal and spatial, integrated environmental modeling, the establishment of operational model and evaluating model, etc. It has the significance and value to study deeply on these.

REFERENCES


