Proceedings of the 33rd Chinese Control Conference
July 28-30, 2014, Nanjing, China

Research on Standardized Development Method of Scenario for Combat Information Simulation System

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Abstract: Analysis and design of simulation scenario, design and application of scenario system are problems needed to be solved in the development and performance verification of simulation system. Consequently, a standardized development method for developing scenario based on a kind of combat information simulation system is proposed in this paper. Firstly, according to the requirements for generation of scenario which are decided by simulation system, the combining of military conceptual model and the entity oriented modeling method (EATI method) is used to build scenario structure model accurately and without distortion. Secondly, description of content and realizing form for scenario are constrained and standardized by extensible markup language (XML). Finally, a visualized and flexible scenario system model is built based on former theory analysis, which is independent of simulation system. This paper not only solves the problem existed in scenario and scenario system, but also implements rapid development of scenario, which provides important theory guiding meaning.

Key Words: Scenario, Military Conceptual Model, EATI Method, XML Schema, Combat Information Simulation System

1 Introduction

The purpose, trend and development situation of combat for both sides in simulation system are assumed by simulation scenario，which is mainly utilized to evaluate the combat by driving the simulation system. Scenario is an essential part for developing simulation system, which can truly reflect the disposition of troops and operation plans in both sides' forces. It is utilized in the simulation experiments, which can assess and verify the technical indicators and operational performance for weapon equipment and simulation system [1]. With the expansion of the scale of distributed simulation system, scenario has become a popular research spot.

Currently, studies on scenario are mainly laid in two aspects. On one hand, it is about analysis of scenario based on conceptual models. For example, Conceptual Models of the Mission Space (CMMS) is developed by U.S. Department of Defense to establish the authority and consistent description of the common starting point for scenario. The content of the research includes how to establish functional description of entity, process, environmental factors, relationships, and interactions of military mission, actions and tasks in the real world [2]. On the other hand, it is about research on implementation tools for generating and editing scenario. Such as Scenario Toolkit And Generation Environment (STAGE) [3] and Scenario Generation Toolset (SGT) [4], which are respectively developed by Canada VPI company and Aegis Research Corporation.

*This work is supported by the foundation for innovative research group of the National Natural Science Foundation of China Grant, No. 61321002, the National Science Fund for Distinguished Young Scholars, No. 60925011, the Yangtze River scholars team of Ministry of Education, No. IRT1208, Chang jiang Scholars Program.

2 Research Background

2.1 Existing Problems in Scenario

Studies on scenario have made certain achievements in China [1, 5]. However, because of lacking in the combat theory, and simulation technique, the progresses of studies are relatively slow. What's more, the unified standards of the content, description and development methods for simulation scenario are not provided. Scenario is developed based on a specific system, where the main problems include misunderstanding, confliction, resources, heterogeneity [6], cooperation and fidelity. These problems are essentially attributed to analysis and design of scenario, design and application of scenario system.

2.1.1 Analysis and Design of Scenario

Nowadays, the problems in the analysis and design of scenario are mainly laid in two aspects, namely content and form. In the content, the research aims at establishing a high-level conceptual model of the static structure, properties, and dynamic behaviors in the simulation system, which is under the guidance of military rules. While in the form, in order to unify the format of scenario description, adopting suitable designing standards to describe each element structurally is needed.

(1) Issues in content of scenario

The military personnel and the simulation developer have known different fields of knowledge. Therefore, there exist some problems between them, such as misunderstanding the application of the same system, lacking in describing interaction process versatility and reusability, etc. The main problems existed in the content of scenario are as follows:

a. Because of lacking understanding in military tasks and their description, military combat scenario is hard to be directly utilized by simulation developers.

b. Scenario is high coupling with the simulation models, which results in poor reusability and independence of scenario data.

The main reason for these problems is the lack of universal, standard structured description methods. Content description of simulation scenario should follow a certain standard, or follow a universal concept description library, which is similar to the Conceptual Models of the Mission Space (CMMS). The concept of devices, entities and processes should be included in the common concept description library, so that the fighting tasks, events, actions, and attribute information in the process of fighting can be structurally described with standardization and unambiguously.

(2) Issues in form of scenario

Owing to the complex content of scenario, scenario should be designed based on a certain designing standard. A designing standard is commonly embodied by a scenario description language. A scenario description language is a set of rules, which is utilized to restrict the format of scenario, as well as monitors the output content of scenario [1]. And an extensible and reusable scenario description language can satisfy the need of diverse HLA simulation systems.

Completeness of the design, extensibility, availability of domain experts, reliability and expression ability are the standard to judge a scenario description language. The features of a scenario description language are as follows [1]:

a. Flexibility: Dynamic exchange, description of the object-oriented real model and unified interface specification should be allowed in the design of scenario, so that the need of scenario for new applications can be satisfied by setting the system structure in case of not revising the codes.

b. Hierarchy: Scenario is designed to meet the requirements for different resolution simulation systems, That is to say, it simultaneously satisfies the simulation requirements of device-level entities, platform-level entities and aggregation level entities.

2.1.2 Design and Application of Scenario System

Scenario system edits and revises scenario by a visualized environment, which decreases the workload for scenario editing significantly. The purpose of scenario system is to depart the development of scenario from simulation system. A rational scenario system adopts a flexible and hierarchical language to realize the hierarchical and modular of scenario. In addition, the following standards for scenario system should be satisfied:

a. Friendly situation interface. A three-dimensional situation window is provided for scenario makers, which consists of a friendly graphical interface and a situation display interface.

b. Flexibility and control for simulation models. Supports for the dynamic simulation models are provided.

c. Independence. In order to realize the universality of a scenario system, scenario editing should be independent of simulation systems.

2.2 Demand of Scenario for Combat Information Simulation System

In this paper, combat information system focused on a weapon platform, with functions of target recognition and tracking, threat assessment, data processing, arms control, fighting against the enemy. Compared to the scenario need for common simulation system, there are some difficulties in developing scenario for combat information simulation system:

a. Verification for task flow and information flow is the key point in establishing scenario.

The generation and flowing of information is the most important factor to establish combat information simulation system. The entities are identified according to the retrieval, transmission, processing, and application of the information. Therefore, all kinds of information in the process of operation should be described completely and accurately.

b. Flexible configuration and description on multi-task and multi-resolution scenario.

A variety of combat tasks are supported by combat information simulation system, and many entity models and complex equipment are involved. In general, resolution of an entity is decided by the command and control hierarchy in general simulation system. Such as several aircrafts are abstracted as a formation of aircraft, or single tank is abstracted as an individual entity, etc. However, production and flowage of information are the most important factor for the construction of combat information simulation system, and the role of command and control hierarchy is relatively declining. In combat information simulation system, according to tasks and purposes of simulation, a kind of battle plane can be depolymerized as relatively individual equipment subsystems with high resolution. Therefore, in order to verify technical indicators for combat information simulation system, the construction of scenario should have been well in extensibility and flexibility.

Based on the problems mentioned above, a standardized development method for scenario is proposed. The combining of military conceptual model and entity analysis method (EATI) is firstly adopted to build simulation scenario structure model accurately and without distortion. And then, the description of content and realizing form for scenario are constrained and standardized by XML Schema. At last, a scenario system is designed based on former theory analysis, which is independent of simulation system, and is successfully applied in a certain combat information simulation system. Therefore, the problems in the development of scenario are solved by the standardized development method, which satisfies the requirements of scenario for combat information simulation system at the same time.

3 Analysis and Design of Scenario

3.1 Basic Concepts and Features of XML

XML is an original language which allows users to define their own makeup language. It can define a set of rules of semantic markup, which can be defined by a DTD or Schema. Compared to DTD, the using of namespace in Schema has

made XML more scalable, normative and general. As a data representation method, XML has many significant advantages [7]:

a. Self-description. XML file contains rich semantic information, which includes completed definition of data structure and constraints. So it can be easily identified by the computer.

b. Platform-independency. The portability of XML is strong, which can be served as a medium of information transmission between different platforms.

c. Structured and hierarchical. XML is stored in the form of a tree hierarchy, which only has one root as a child element. Besides, a child element can contain its own sub-elements, so XML has the characteristics of good structured and hierarchical.

As a result, XML document is very suitable to be the scenario description language of combat information simulation system. Using XML Schema to describe scenario has many advantages, which include making the military personnel and the simulation developer working together in the development of scenario, as well as realizing description of scenario with generality, accuracy and scalability.

3.2 The Development of Scenario

Simulation scenario is different from the military combat scenario, which is designed for assuming the initial situation and the operation process of simulation system. It is mainly utilized in driving simulation system for assessment and validation. Combat information simulation system is built to reconstruct the operation process of actual system in the real world. So in order to ensure that the simulation system is consistent with the actual system, scenario should depend on the military combat scenario to a large extent. Scenario extracts the content of military combat scenario. After that scenario is reconstructed in a structural and formalized form, which is in accordance with requirements of simulation system. But there exists a disadvantage that the military combat scenario cannot be directly utilized by simulation developers. In order to overcome the disadvantage, the most crucial problem is how to convert military combat scenario to scenario reasonably and without distortion.

Military conceptual model is consistent with the description of the world military operations. It draws on the conceptual model of mission space (CMMS), which constructs a bridge between the simulation developer and the military personnel [8]. Military combat scenario can be described based on some modeling methods, which can guarantee the development of scenario with non-ambiguity and consistency. That's to say, military combat scenario should be modeled by a certain method, which can be easily understood by both military personnel and simulation developers. And the models of military combat scenario will be stored in the military model library which can be extracted and invocated by them.

So far, military conceptual model has four modeling methods, including the process oriented modeling method, the ontology modeling method, the object-oriented modeling method and the entity oriented modeling method. The entity oriented modeling method (EATI method) has been the research emphasis for military conceptual model. Comparing with other methods，it has apparently advantages. EATI method uses four elements which include Entity, Action, Task, Interaction to describe the combat process, which weakens the difference between the solving domain and the problem domain [9]. EATI method is beneficial to achieve agreements on research problems between the military personnel and the simulation developer.

The problem of analysis and design of scenario can be solved by the combining of military conceptual model, EATI method, XML Schema. The method for developing simulation scenario is described as follows:

Military combat scenario is described by EATI method and stored in the military conceptual model library. And this process is completed by the military personnel. Scenario is also described by EATI method according to the demand of the simulation system. The structural description of scenario is constituted of battle plans, basic attributes, and environmental information. Entity, action, task and interaction which make up the battle plan are extracted from the military conceptual model by the simulation developer. The structural description of scenario is mapped into the formation description of scenario by XML, and the content of scenario is constrained by Schema. The detail process is illustrated as Fig. 1.

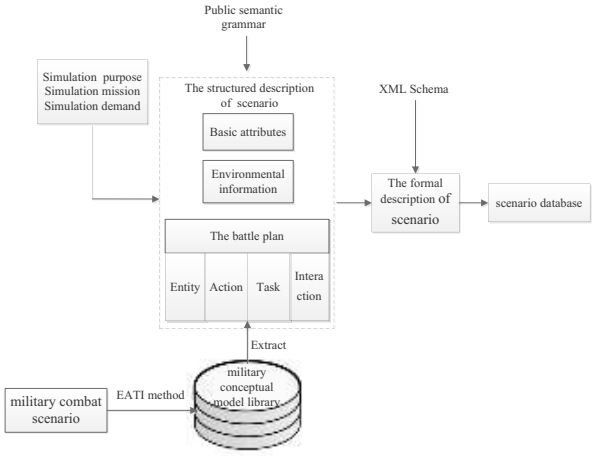

Fig. 1: The development process of simulation scenario

The structure of simulation scenario is shown in Fig. 2.

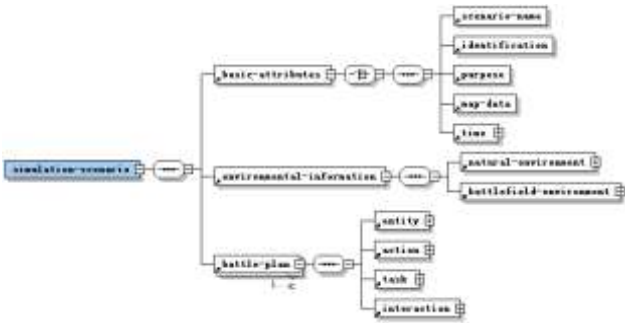

Fig. 2: The XML Schema description of simulation scenario

Some basic information of scenario is described by "basic-attributes" sub node, which include scenario-name,

identification, purpose, map-data, time, etc.

In general, environmental information is mainly constituted of natural environment, battlefield environment and strategic environment. In this paper, based on the characteristics of combat information system, the "environmental-information" child node only contains natural-environment and battlefield-environment. The natural-environment is mainly represented by wind-speed, temperature, air-pressure, rain, thunder, lightning, etc. The battlefield-environment is mainly described by combat-background (such as steppe, plain) and related description (such as operations-range, operations-center).

The granularity of battle-plan is 1 +. It represents that a scenario contains multiple battle-plans in different purposes. The content of the "battle-plan" is described by EATI method, and its formal description is realized based on XML Schema.

3.3 The Description of "battle-plan" Based on EATI Method

3.3.1 Entity

In the combat information simulation system, the entity has certified behavior ability. It is the subject and object of all military forces that involved in the simulation, such as command facilities, friendly forces, enemy forces and equipment of weapon platforms, etc. Attributes are utilized to describe the entity. There are varieties of entities with different resolution in the combat information simulation system. Consequently, each entity is analyzed and summarized to form a standardized and structured entity description template. Without loss of generality, entity is described by basic-attributes, spatial-attributes, motion-attributes, behavioral-attributes, state-attributes and configurations. Basic-attributes include name, number, assignment and superior-ownership, which is the general overview of the entity. Spatial-attributes refer to the position of the entity, which is represented by longitude, latitude and elevation. Motion-attributes refer to the entity with information about velocity and acceleration, which are the description of the real movement. Behavioral-attributes describe abilities of entity. State-attributes are carried out to describe the current status of the entity, such as pressing, mutilating, detection, etc. Configurations are the description of damage weapons and their damage effect which owned by the entity. The XML Schema description of "entity" child node is shown in Fig. 3.

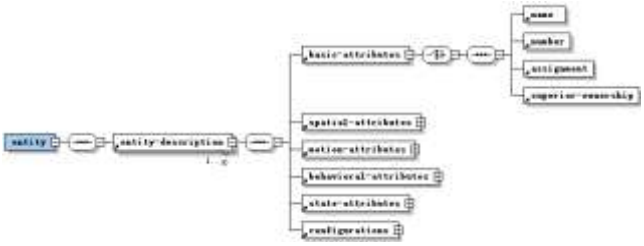

Fig. 3: The XML Schema description of "entity"

3.3.2 Action

When an entity is in a state of continuous process, the continuous process is called action. According to the time span and the complexity of the action, it can be subdivided into behavior and process. Generally speaking, an ordered set of behavior is called process. Besides, process is carried out based on the time of action and the execution sequence of behavior, which is constraint by process control rules. Based on the characteristic of action in the combat information system, action is described by action-name, identification, action-time and action-area, behavior-sequence, sequence-control. The XML Schema description of "action" child node is shown in Fig. 4.

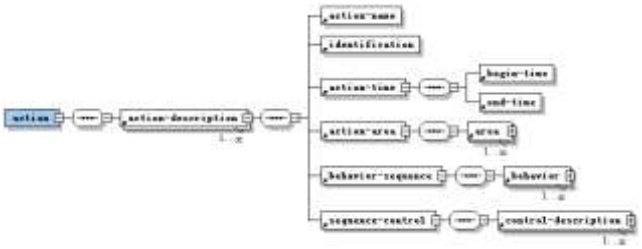

Fig. 4: The XML Schema description of "action"

3.3.3 Task

Task is one or more action process which is performed by the entity with definite purpose and intention. Task is constituted of multiple action sequences with an explicit combat significance. Essentially, execution process of a task is the implementation process of actions. Task is represented by purpose, task-number, execution-entity, target-entity, executive-condition, action-sequence, and sequence-control. The XML Schema description of "task" child node is shown in Fig. 5

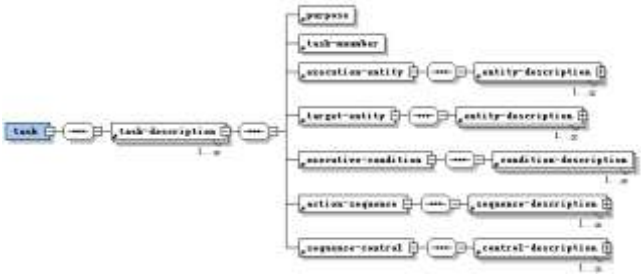

Fig. 5: The XML Schema description of "task"

3.3.4 Interaction

In this paper, interaction is the description of mission flow, information flow in combat information simulation system. Interaction is produced by an entity that would influence another entity. Interaction and action are closely related, therefore, the description of interaction depends on the description of action to a large content. If the action of an entity would affect the other entity, or the action of an entity changes its own state, the other entity is influenced by this

change, there is an interaction between the two entities. The XML Schema description of "interaction" child node is shown in Fig. 6.

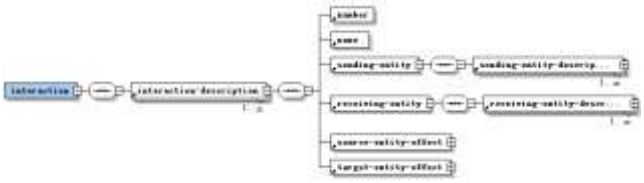

Fig. 6: The XML Schema description of "interaction"

4 The Design of Scenario and its Application Example

The analysis and design method of scenario which used in combat information simulation system is put forward in the previous section. The scenario system is designed and implemented to verify the proposed method in this section, which is independent of simulation system.

The scenario system is mainly composed of the programming control management module, the scenario editing module, the situation plotting module and the scenario storage and export module. The architecture of the system is shown in Fig. 7.

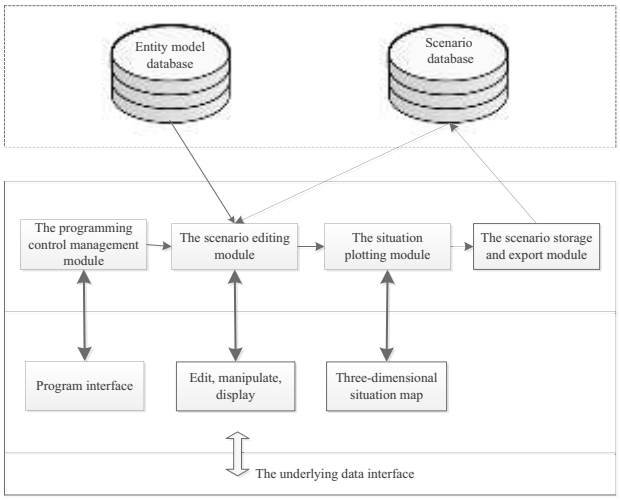

Fig. 7: The structure diagram of the scenario system

a. The programming control management module: It is responsible for controlling the start and exit of the scenario system, the database connection and interruption of basic operation, and managing the simulation scenario files of the scenario database, which included the operations of retrieval, load, and delete.

b. The scenario editing module: It provides a friendly man-machine interface for the maker with the functions of editing and modifying simulation scenario, which include the entity's information and deployment, the number and weave of entities, editor of a battle plan. Besides, entity models are allowed to add，delete and modify, which the hierarchical and structural of entity models are fully considered.

c. The situation plotting module: it uses the geographic information system (GIS) to plot the initial situation for both Red and Blue. The initial situations of both sides are gained by scenario makers through the analysis of the combat purpose, and then the interface functions of geographical information system are utilized to draw the initial situation.

d. The scenario storage and export module: The completed simulation scenario is output in the form of XML file, and then it is deposited in the scenario database, which the separation of scenario editor and data storage, improving the efficiency of simulation are realized. The scenario file formed by XML can realize the check of scenario data syntax and makes the computer process automatically and easily.

Fig. 8: The main interface of the scenario system

Based on the research mentioned above, a simulation scenario system for a certain combat simulation information system is realized. The main interface is shown in figure 8. The top-left of the interface is repository, which displays drag entity component models. The down-left of the interface shows the entities in scenario editing. The right of the interface can edit the information on all aspects of the chosen entities. In the middle part, it is the three-dimension map plotting based on military geographic information system for the secondary development tendency. When saving scenario files, it will strictly check them according to the Schema of simulation scenario, which largely improves the standardization and reusability of scenario. The system can satisfy the scenario generation requirements for a certain combat information simulation system and has strong flexibility and openness.

5 Conclusions

The problems which existed in the development of scenario are analyzed in this paper. In order to solve these problems, a new method for developing scenario based on a kind of combat information simulation system is proposed, and the scenario system which is independent of simulation system is designed. Therefore, the generation process of scenario is standardized. According to the studied results of this paper, a variety of special scenarios are generated and applied in a certain combat information simulation system. It not only satisfies the requirements of the certain simulation system, but also has certain reference significance in realizing deduction of simulation system according to scenario.

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