The Study of Simulation Architecture in Meta-Synthetic Hall

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Abstract. The meta-synthetic methodology is the scientific and effective way to solve the problems of the complicated large system. Through the meta-synthetic Hall, we combined the expert, repository, and simulation test together, building an environment to realize the Meta-Synthesis methodology. In this article, we put forward simulation architecture for the Meta-Synthesis Hall. With the architecture, we can build the simulation system and do experiment for the Hall, supporting expert discussion and repository accumulation. We can solve the system experiment and data collection problems for complicated large system analysis, enforces system improve and perfect.

1. Requirement
The complicated large system consists of many functional subsystems, which hinge and merge each other, is a highly synthesis and integration system. It is a huge and difficult work to construct and research Complex land system; there are a lot of uncertain and complicated factors. To construct the system is facing great difficulties and risks.

In order to solve the problems in the process of constructing complicated large system, and reduce developing risk, it is become more important to built a suitable demonstrate method in the developing complicated large system. The Meta-Synthesis method [1] based on simulation is an effective demonstrate method to carry out complicated large system.

Through the simulate architecture, we can build the parallel simulation system which can replace real complicated large system for some degree to analysis the real system. With the simulation and other systems, we can build the Meta-Synthesis Hall which can put forward Meta-Synthesis method conveniently and support the research on the complicated large system efficiently.

2. The Meta-Synthetic Hall based on simulation
The Meta-Synthetic Hall is a concrete application of meta-synthetic methodology. The Meta-Synthetic Hall consists of three parts: expert system, machine system and knowledge system, the expert system and machine system is the carrier of knowledge. The three system combine high intelligently to form man-machine system, not only has the knowledge and information collection, storage, transmission, analysis and synthesis function, more important is has the function to generate new knowledge and intelligence.

2.1. The Meta-Synthetic Hall architecture
The Meta-Synthetic Hall based on simulation is a special application of the meta-synthetic hall using system simulation [2] technology. The Hall was build based on the simulation test, the expert
demonstration and information resources. The Hall organizes simulation system, expert group and the information repository together with the distributed interactive network, is shown in Figure 1. The Hall form a kind of high level matrix system, vertical hierarchy, horizontal distribution and interaction each other. The Meta-Synthetic Hall Based on Simulation provides a standardized, structured form to solve the problem of the complicated large system.

The Expert Group is core of the Hall, was constituted with the persons from all kinds of related field. They not only give the question that we met, but also put forward the project to solving the question. Of course, the project is the hypothesis first, but in the end it will become the true mostly. The Expert Group is the intelligent generate place, it cannot be replace by any machine. With the help of simulation test and repository information, The Expert Group can adjust and optimize the project to meet requirement of the question.

The Simulation System is the parallel system of complicated large system (it may be exist or may be not) with simulation technology. The simulation system has same characters with the complicated huge system and can replace it to some extent. It is serial and has different accuracy level; it may be simple and may be complex to satisfy the requirement of the research. The most important function of the Simulation System is the test on it. The Simulation System can run all kinds of tests that were give out to verify the project of the Expert Group, and generate the data to be analysis by experts.

The Information Repository is a huge database, it store and manage all the data of the complicated large system. The expert and simulation test can get all the information they need from the Information Repository and put the new information into it also. How to organize the huge information with high efficiency is the big problem the Information Repository will meet.

2.2. The procession of Meta-Synthetic Hall

In order to study the complicated large system, we need to do a series science and experience activities. The Meta-Synthetic Hall Based on Simulation follows the scientific and experiment integration means, combining intelligence and knowledge. The Hall has the ability to study and solve the problem of the complicated large system.

The Meta-Synthetic Hall Based on Simulation is an autonomous system and operates with the definite process, is shown in Figure 2, generally the process have five phases. First, we should give the problem related with the complicated large system to The Hall, experts of the Hall need explicit the problems in order to analysis it. Then, the Expert Group will study the complicated large system to get the project that should solve the problems. Third, the Hall should build the simulation system of the complicated large system and put the information related with the system into the repository. Fourth, the Hall carries out the tests according with the requirement that study need and record the test data into repository. Fifth, the experts analysis the data in repository and evaluate the efficiency of project. If through the experiment we can prove the project can solve the problems, the Hall will get the conclusion and give out the project to solve the problem of the complicated large system, otherwise, the Hall will
began the other circle at second phase. Generally, the Hall should circle the process many times to get the conclusion, and in the process the Hall need to interchange information with other system frequently. So, the Meta-Synthetic Hall itself is an open, dynamic system, continuous development and evolution.

**Figure 2.** The procession of Meta-Synthetic Hall

3. **The simulation test system**

In order to support the complicated large system research and analysis, we need to build a large-scale simulation system. The simulation system is the parallel system of the actual system, they are similarity, but different actually. The simulation system can be construct, virtual, or live system [3] to be built with the simulation technology. It have the same component, logistic, characteristic with the actual one, but it is simply and can be destroy and rebuilt repeatedly many time easily. Because we cannot test with the actual complicated large system frequently, for example the globe, the society, the war, the environment, so we need to build the simulation system to study the actual complicated system.

For the different research purpose, we can build different simulation system to satisfy the different requirement. One complicated large system can have many simulation systems, some are complex, and the other may be simple. Simple or complex is not important point; the important is that the simulation system can replace the actual one to some extent and at some field, so the test at the simulation system should be same with the actual system. Generally speaking, the simulation of complicated large system is a huge and difficult work, and the simulation system is also complicated. We need to spend more time and money on it to build a parallel simulation system; it is comprehensive and accuracy enough with the research on the system.

**Figure 3.** The simulation system architecture

For example, with the efficiency research of the complex land system, we build a simulation system to launch test. The simulation system of the complex land system include: environment simulation system, computer generate force system, man in the loop control system, information display system, HLA/RTI [4], system control and other related systems, is shown in Figure 3.
3.1. The force generate

Computer Generate Force System is the subsystem of simulation system to generating simulation entities of combat force. The simulation entities have the ability to decision and activity, simulate all kinds of force unites, including fighting unit, command unit, communication unit, and detection unit, ensure unit, etc. they can simulate weapon ability, operation activity, information transmission, equipment and logistics insurances, etc. The Computer Generate Force System reflected combat effectiveness of the complex land system.

In order to improve the unity and efficiency of develop CGF system, we put forward a common model structure [5] for all kinds of weapon system entity as shown in Figure 3. The common model structure have nine kinds of common modules, the module has a serials fixed interfaces which can ensure the entity run smoothly. With the structure, we can build every kind of weapon system entity through assemble different kinds of modules in the CGF system. With the same model structure, entities can interact each other easily by the unity interfaces which have been defined in the common structure.

The modules of common structure must could cover as large field as possible, to meet the different requirement of all kinds of weapon system entity. So we divided eight kinds of modules in the common model structure, including command and control module, communication module, detector module, motility module, protection module, strike module, service module. Every kind of model has special structure and interface based on the real function characters in real weapon system. Every simulation entity in the CGF system can be assembling by some kind of modules according with the concrete condition of the real weapon system. In the different kind of entity, the module maybe has different achievement method, but they must have unity structure and interface.

The interface of structure is other key in the common structure, which connected the different modules together to form the simulation entity of weapon system. The CGF system has an interface list which is defined in the common structure, every interface in the list should be defined concretely in the system. Every module fixed some interfaces from the list, but they can’t change them. Through the interfaces, the different module can interact each other in the simulation entity or beyond it.

3.2. The man in loop simulation

Man in the Loop system [6] is the subsystem of simulation system to give the platform which put the human being into the simulation system, lead in the perception, analysis, judgment, decision, and executive ability of the person. The person in the simulation not only input signals to the system, but also sensing variety output signal of the system. Man can make decisions according to the variation of system output signal, and feedback at the same time.

Man in the Loop system is mainly used in the field of user training, operator interface design, teamwork training, the relation analysis of man and weapon. In these fields, the most accurate artificial intelligent system still can’t accomplish the task, the man in loop is the only way to realize the precisely simulation. The forms of the man in loop system include virtual reality system, training simulator, and network drilling system.

The virtual reality system is a major man in loop simulation system which was used in the early stage. With the virtual reality technology, the simulation system can built the virtual object and environment that is realistic with really object you want. The virtual reality system is also suitable to build the object which is a concept one, so it is superiority with the study in the concept stage. The virtual reality system uses the three dimension graphic and multi-sensor input technologies to build the virtual object. Generally the virtual reality system comprises three parts, including function deployment platform, tracking and positioning module, and human manipulating module. The system can simulate the visual, auditory and tactile conditions for the user and at the same time it can realize interact between the virtual object and real person.

3.3. The environment simulation

The Environment Simulation System is responsible for generating land, sea, and air environment for the simulation test. The system was able to provide dynamic simulation of battlefield environment, produce
the real-time data of environment, and meet the requirements of complex land system simulation for the dynamic environment data change. The forces simulated by the Compute Generated Force System have to run under the constraint of simulation environment. The system was able to objectively and accurately reflect the environment effects on the force unities operation. The Environment Simulation System has six modules to achieve different function, including simulation control, scenario compile, dynamic simulation, information display, data publish, and database compile.

The environment simulation was control by the control federate in the environment simulation federation, the other federates will accept the instruction from the control federate and execute it to ensure the environment simulation running normally. The scenario compile module can compile the environment scenario file to instruct how to build and run environment with simulation part, and the user can edit the parameter of the environment easily, especially for the atmosphere and ocean parameters.

Dynamic simulation module is the core part of environment simulation, it can simulate land, atmosphere, ocean, and space change continually. At the same time, it can support CGF system through providing various services to CGF, including road topology, obstacle interdiction, and other information. The information display system can provide vary kinds of view for environment information and support the information search with specific time and position. Database compile module is deal with kinds of original data, the original data must be convert, cut, clean, and mix to generate the product data for CGF and other users.

3.4. The data record and replay
The Multi-Info Display System will visualize the information of simulation test in the process. The simulation process can produce all kinds of data, and the amount of the data is huge. How to see and realize the huge data is a big problem, the graphical of the data is the efficiency method to solve it. Through different kinds of information display way, the Information Display System cans convenience the scientific person to analysis and study of simulation test data.

The Multi-Info Display System can display simulation data distinctly in three dimensions, the user can view the kinds of data which was produced by simulation in real time and in late time by replay. Through the display system, the user can cruise in battle field and acquire each side force deployment. The display system comprise four parts, including status control, three dimensions generate, synchronize handle, and edge fuse. The display process is driven by data from the CGF.

3.5. The other systems
The simulation system has other kinds of subsystem to maintain the simulation run smoothly, including simulate Control system, record system, playback system. Simulation control system is responsible to control the simulation process, record system can record simulation data completely, and playback system can run simulation process once more with the simulation data.

4. The simulation experiment for the Meta-Synthetic Hall

![Simulation Diagram]

In the Meta-Synthetic Hall, the simulation system is the major role to complete the experiment which is used to test and evaluate the object. The object and problem in the MSH is very comPLICATE and cannot get conclusion through the simple discussion. Usually, we need to do lots of experiments to get useful
data, and through analysis the data to support expert discussion. The experiments are verity and include logic, physic, simulation experiment, and so on. With the development of the computer, network, simulation technology, the simulation experiment has become a major tool to support expert discussion.

4.1. The superiority of simulation experiment
The simulation system can implement experiment for the concept system which only stay on the paper no physical. When we face a new system which wasn’t be built, the big problem is how to do the experiment with it, otherwise we can not to find the mistake in the design of the system, especially for the concept model. If we cannot solve the mistake in the initial stage, we would spend more time and resources in the fellow stage. The simulation system put forward the solve solution to this situation, we can build a simulation system, it have the same property with the physical system. The simulation system is a parallel system of the physical one, through the experiment of the simulation system, we can analysis and evaluation the physical system of the future, improving design and helping build a reasonable sterol system, as shown in figure 4.

Simulation experiment has superiority of high efficiency and low cost. In the process of simulation experiment, we needn’t to build lots of physical model, just need to develop the digital models and to assemble the simulation system. So, we can increase the experiment efficiency greatly, building the simulation system quickly and put forward lots of experiment, and need not to do much more preparing work for every experiment. At the same time, the simulation experiment cut down cost hardly, not only save lots of money to build the physical model, but also reduce the cost of the experiment itself.

4.2. The shortage of simulation
Although the simulation experiment has above mentioned advantages, it still cannot replace the physical experiment. Because there are essential referents between simulate and physical experiment, the simulation system cannot reflect all character of the real system forever. So the simulation system can help solve lots of mistakes for us, but cannot replace the experiment of the real system. The real system experiment is the final stage to evaluate the efficiency of the real system. In the Meta-Synthetic Hall, there are simulate and physical system to be both exist usually, the compare between the simulation and real system experiment can improve and perfect the function of system. For the study of complicated system, the simulation system has more useful value, for the application of complicated system; the real system is the final target.

5. The conclusion
The complex land system is an open complicated giant system, so the system research and development need more scientific systems engineering methodology. The meta-synthetic is the scientific methodology to solve giant complex system problem. Through combining expert panel, simulation system and repository, we can build Meta-Synthetic Hall. The Meta-Synthetic Hall based on simulation is the scientific and effective way to solve the problems of the complex land system demonstration and construction.

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