Research and design of real time estimation systems

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Abstract: - In this paper, we design a real time estimation system in complex system simulation research. The popular simulation technology High Level Architecture (HLA) is introduced. The logical structure of the system is constructed with three levels of data resource, component and application. The main functions of the system are given, including sample collection, real time estimation, result display, replay control and rollback control. Then the realization of the system is analyzed. The web-based display system, the replay and rollback control are discussed in detail. Finally the paper concludes with summaries and further developments.

Key-Words: - **Real time estimation, Complex systems simulation, High Level Architecture, Replay, Rollback, Web**

1 Introduction

Modeling and Simulation (M&S) has become an important way in nonlinear systems research. With the development of modern science and technology, the architecture of simulation systems has evolved from centralized to distributed, from closed to open and interactive. And simulation technology has undergone a series of stages, such as single computer-based simulation, Simulation Networking (SIMNET), Distributed Interactive Simulation (DIS), Aggregate Level Simulation Protocol (ALSP), and High Level Architecture (HLA). HLA is published by U.S. Department of Defense (DoD) in 1995, which establish a common technical framework to facilitate the interoperability of all types of models and simulations. It builds the star-structure with the center of Run Time Infrastructure (RTI) separating simulation and communication and providing efficient communication to logical groups of federate. The general structure of HLA is shown in Fig.1.

HLA consists of HLA rule, Object Model Template (OMT) and Interface specification to realize the Interoperability and reusability of simulation systems. Besides, HLA adopts Object Orient Technology and all the models interact with each other through flexible data structures defined in OMT files. It is convenient for user to construct all kinds of models. As a result, it is more and more widely used in complex system research, such as multidimensional systems, nonlinear systems, combat systems, etc.

During traditional HLA-based simulation, user models interact with each other through RTI and the interaction data are collected and restored to data files. When the simulation is over, the collected data are decomposed and loaded to databases for estimation. The deficiencies of the above system estimation are obvious that users can not know the simulation result in time. Especially if the simulated system is very complex with huge simulation data, users will wait for a long time to estimate the system. In order to solve this problem, we design and implement a real time estimation system in HLA environment. The logical structure, the basic functions, and realization are given.

The rest of this paper is organized as follows. In section 2, we analyze the logical structure of the real time estimation system. In section 3, we explain the main functions of the system. We analyze the realization of the system in section 4. Finally, we conclude with current work and considerations for the future.

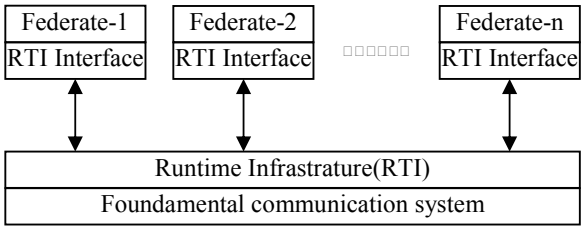

Fig.1 The general structure of HLA

2 The logical structure of HLA-based real time estimation system

We design the whole system with three levels, which is shown in Fig.2. To begin with, data resources are collected and saved in relational databases, including simulation interaction data, scenario data, model structure data etc. Then we develop special components to utilize these data for various applications. For example, the simulation interaction

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data are recorded by Sample Collect component. And data samples are analyzed by Estimation Algorithm components. The main algorithms involve Analytic Hierarchy Process, Exploratory Data Analysis, and Neural Networks etc. Simulation rollback and replay control are realized by the corresponding components. Finally, based upon the above data resources and components, users can make their researches in the related application fields, such as multidimensional systems simulation, nonlinear systems simulation etc.

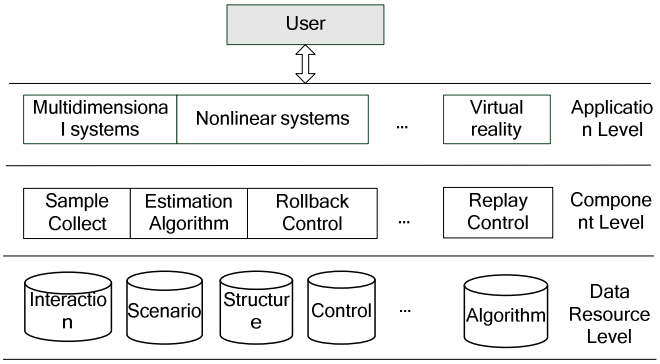

Fig.2 The logical structure of the system

3 The main functions of the system

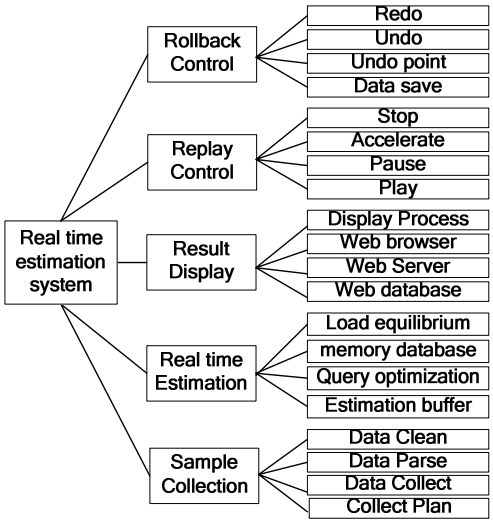

Fig.3 The main functions of the system

The main functions of the system are shown in Fig.3. The sample collection is the basic function. Generally, it will produce large amount of data of complex system simulation. Obviously, it will result in efficiency troubles. To solve this problem, the simulation data are selectively collected according to the predefined plan. As the data acquired from RTI are binary data block, they need to be parsed and cleaned for estimation.

Real time estimation is the key function. Some measures are taken to insure the timeliness, such as estimation buffer, query optimization, load equilibrium etc. The adoption of memory database is an effective way to save estimation time. Besides, the SQL functions supplied by memory database do much help to the estimation process. For example, the simulation and estimation data saved in databases can be easily managed.

As the estimation is performed intermittently, the temporary estimation result is presented contemporarily through web-based display systems. It has the benefit of convenience and independence of operating systems. For instance, even if the simulation is running in a remote laboratory, users can comfortably view the estimation result through web browser in their own offices. At the same time, users with different operating systems, e.g. Windows, Linux etc, can view the result simultaneously.

During the simulation process, there may be some unknown errors or some key point events. Users often want to review or rollback the estimation system. Hence there are functions of Replay and Rollback Control. The general steps of Replay and Rollback Control are listed in Fig.3.

4 The realization design of the system

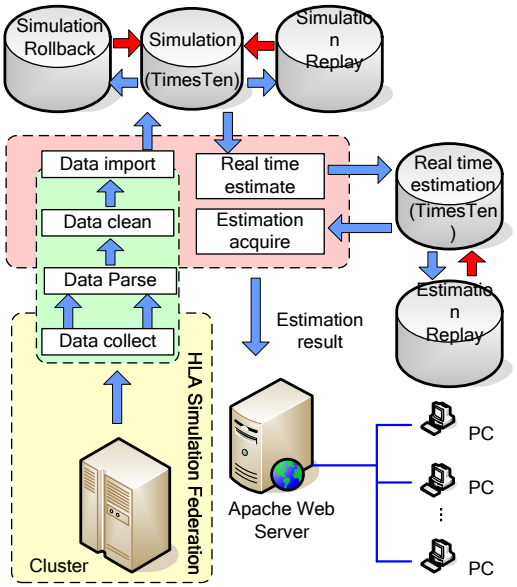

Fig.4 The whole structure of the system

Based on relational databases, the whole systems are designed in Fig.4. Initially, the simulation data are collected from HLA simulation federation. By the steps of parsing and cleaning, they are imported into the simulation database. Then they are further estimated and saved to the real time estimation database. Finally, the estimation results are acquired by Apache Web Server and displayed to all client PCs.

In consideration of timeliness and efficiency, oracle In-Memory database, i.e. TimesTen may be chosen for simulation and estimation data processing. In Oracle TimesTen, all the data are calculated and saved in memory. Of course it will save a lot of times.

4.1 Replay control Design

The replay control of the system includes two parts, i.e., simulation and real time estimation replay. Generally, when the simulation or estimation is done, the related data are saved to the respective replay database automatically. In fact, these data contain the information of one whole simulation process. As the simulation times gradually increases, there will be a lost of simulation and replay samples in the replay databases. They are identified by some special simulation flags, e.g., initial simulation time, finished simulation time, simulation federation information etc.

4.2 Rollback Control Design

As mentioned above, there may be some rollback actions in the course of simulation. We judge this by the time step acquired from RTI. In particular, if the new time step is judged smaller that the last time step, a rollback action occurs. Then all the simulation data are truncated according to the new time step. The truncated simulation data are saved to the simulation rollback database. The judgment of rollback process is shown in Fig.5.

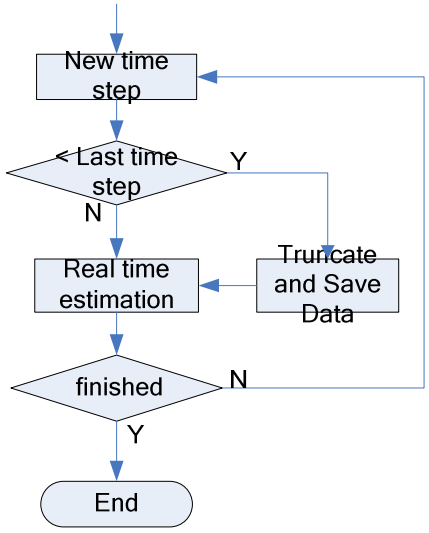

Fig.5 The rollback judgment flow

4.3 The web-based display result

As shown in Fig.4, the real time estimation result is acquired and displayed through web servers. For convenience, Apache Tomcat 6.0 is selected in the system. The result data are generally displayed by web figures and tables. And it can be observed by different client PCs simultaneously. To ensure the dynamic visualization effectiveness, we adopt AJAX technology, which is a popular web-based development model for enhancing application performance and interactivity. A simple displaying screen is shown in Fig.6.

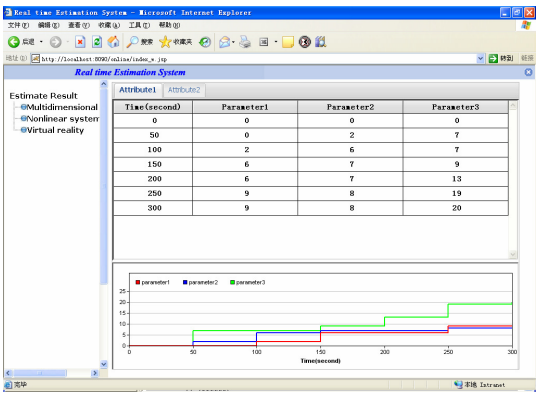

Fig.6 The web-based real time estimation display

5 Further developments

At present, the real time estimation system is designed with a serial architecture. In other words, the simulation data are processed in a sequential order, e.g., data collection, data estimation, data display etc. However, in some research fields, simulations may execute concurrently with samples produced at the same time. It will cause troubles to analyze these samples by the current real time estimation system. To solve this problem, we need to enhance the functionality of the current system to do some parallel work, such as data fusion, data synchronization etc.

Furthermore, as the simulation times increases, the estimation samples in the replay database will increase too. They are abundant resources for system research. Some measures may be taken to deal with these samples, such as data mining, exploratory data analysis, etc. Intrinsic characteristics of the system may be discovered. Besides, such analysis also can also be done in real time.

6 Summaries

In this paper, we put forward a solving scheme of real time estimation in HLA simulation environment. The logical structure, the main functions and the realization are given in detail. It has been used in several complex system simulation fields with a favorable result. Besides, it has the potential usability in huge complex system research, such as combat system simulation, social system simulation etc. We hope it can be referred by other similar researchers.

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