Improvement of IES Wrapper for Plug-in of Advanced Simulation Programs

Sivasithamparam Nallathamby, Student Member, Earthquake Research Institute. University of Tokyo
Hori Muneo, Regular Member, Earthquake Research Institute. University of Tokyo

1. Introduction

Development of a simulation-based earthquake disaster prediction system is a challenge of earthquake engineering of next generation. The simulation-based disaster prediction system is aimed at providing possible disasters which have not been experienced. The system will be a huge computer system since its target is to simulate all three phases of earthquake hazard and disasters, namely, simulation of an earthquake, structure responses, and actions against earthquake disasters.

The authors have been developing integrated earthquake simulation (IES)[1] as a candidate of the simulation-based earthquake disaster prediction system. The number of building and structure types is huge and each type has distinct advanced analysis method which computes non-linear seismic responses. These methods need to be plugged into IES.

In order to include various kinds of buildings and structures, IES makes use of a wrapper or a mediate. For a given simulation program (SP) of a particular building or structure, a mediator plays the role of an interpreter so that SP is linked to IES without changing SP and IES. Mediators have been built for several non-linear SP's of RC or steel piers, ground molds, and wooden houses. These mediators, however, are at a primitive.

2. Strategy of Improving Mediator

In developing a large computer system, it is generally expected that system follows the KISS (Keep It Simple, straightforward) principle, so that developers or users have easier access to the system. The major advantages of the KISS principle are to simplify the logic and to have a well-structured code. As the system becomes larger, these two advantages become more significant. Regarding to the first advantage, the current mediator structure is slightly complicated in converting SP's results to visualization data. Of course, it is quite logical to convert SP's results to data of a common structure, which are actually intermediate data of the visualization process since they are re-converted to data of specific form that are used for a particular visualization tool such as POV or AVS. Regarding to the second advantage, the mediator's role of providing input data should be more flexible so that data which are not stored in GIS can be used.

Based on the above discussion, the authors make the following two strategies of improving mediator as 1) modifying the program structure of the member functions that provide input data to SP; and 2) finding an alternative of generating visualization data as intermediate data. The simple structure of the new mediator is shown in Fig. 1. Adding to GIS, a new element of Structure Data appears; this element is a source of specific data necessary for each advanced SP. Also, instead of producing visualization data, the new mediator directly produces files for POV, VRML or AVS. These files are the results of converting SP-Result.

3. Construction of Mediator for UNIVERES

UNIVERSE[3] is a 3-D non-linear dynamic FEM programs which analyzes a dam-foundation-reservoir system; it is actually a commercial package which has been using by Electric Power Company Co., Ltd (J-Power). Modification of the member function structure must be made, based on the analysis of the data structure of UNIVERSE. A new mediator for UNIVERSE thus modifies the member function of PutStructureData(). PutStructureData() is a function which plays a role of converting data between the data for the dam structure information and the data actually input to UNIVERSE. The structure information is to describe nodes, elements and material properties; information should not be changed, but converted to data expressed in a specific format of UNIVERSE. Once the function structure is modified, this change can be made by PutStructureData(); data input to UNIVERSE are automatically changed by means of PutStructureData() for a common structure information.

In Fig. 2, the program structure of UnifiedVisualization() is presented; it has two layers for data sets, a basic layer for the original results of UNIVERSE and a layer for data which replace the previous intermediate data of the visualization process. In this layer, nodes, elements and values are actual data which are made by pointing the data in the basic layer. In this manner, the consistency of the data which are used by several visualization tools is achieved by the minimum effort.

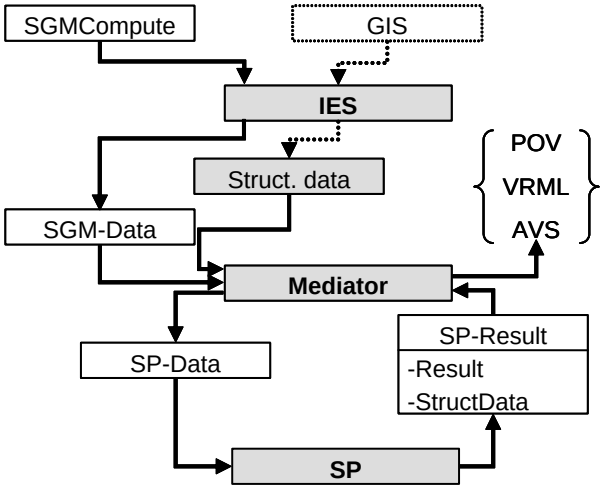

Fig. 1. Roles of new mediator as interpreter between IES and SP converting various data.

Key Words: mediator/wrapper, IES (integrated earthquake simulation), unified visualization
Earthquake research Institute, The University of Tokyo, 1-1, Yayoi 1-chome, Bunkyo-ku, Tokyo, 113-0032, Japan
(Tel: 03-5841-1774, Fax: 03-5802-3391)

4. Comparison with previous mediators

In software engineering, scalability, modularity and interoperability are the desirable properties of a system or process. A system like mediator or a set of mediators is easily evaluated by them. These characteristics are used as an index with which previous and new mediators are compared. Scalability means ability to either handle growing amount of data in a graceful manner. MPI parallel computation is applied to new mediator, in order to meet the demand to handle growing amount of SP's results. On other hand, no parallel computation technique it to enhance its scalability is applied to the previous mediator. Modularity is the property of computer programs that measures the extent to which they have been composed out of separate parts called modules. Though previous and new mediators are coded in object oriented programming, authors have paid more attention to make disposable code which is composed of a number of small, self-contained units in new mediator. Interoperability concept in IT is "the network is the computer." To reach this ability, a system should have a loosely coupled distributed systems built by interconnecting multiple work-stations through a local area network (LAN). Authors are currently not interested in distributed C++ (DC++) because of a computer cluster which has enough capability to handle IES to a sufficient level.

The new mediator has improvement over the previous one in scalability and modularity. In interoperability, however, no improvement is made. Summary of the comparison of the new and previous mediators is presented in Table. 1.

5. Performance of Mediator for UNIVERSE

The performance of the new mediator for UNIVESE can be mainly related to visualization or unified visualization. Authors have applied several visualization tools, such as POV (Persistence of Vision), VRML (Virtual Reality Modeling Language) and AVS (Advanced Visual System) to make visualization images. The mediator for UNIVERSE is used to simulate seismic response of an existing arch dam [4]. The mediator for UNIVERSE has played the role of an interpreter, by handing input data and output results of UNIVERSE completely, satisfying all requirements of IES, as well. Static and dynamic images of the dam for a designated earthquake response are produced.

Just for presentation, the authors have considered a non-realistic situation that the dam is located in the center of a city; the city model is made with the aid of available GIS data. The results of UNIVERSE dynamic analysis are gathered by the mediator's member function UnifiedVisualization(), and the time history of displacement for all the buildings in the city are combined for the unified visualization. In dams in some particular nodes only displacement time is computation is done by UNIVERSE. Since the dam and buildings have quite different scale of displacement due to their dimension, the displacement of the dam and the building is multiplied by a factor of 6 , 20, respectively.

Table 1. Comparison of previous and new mediators.

Index	Previous	New
Modularity	Medium	High
Scalability	Low	High
Interoperability	Very low	Very low

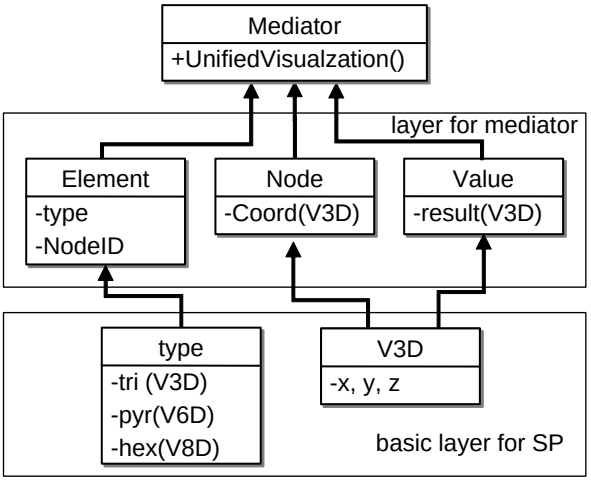

Fig. 2. Layered program structure for member function of UnifiedVisulzation().

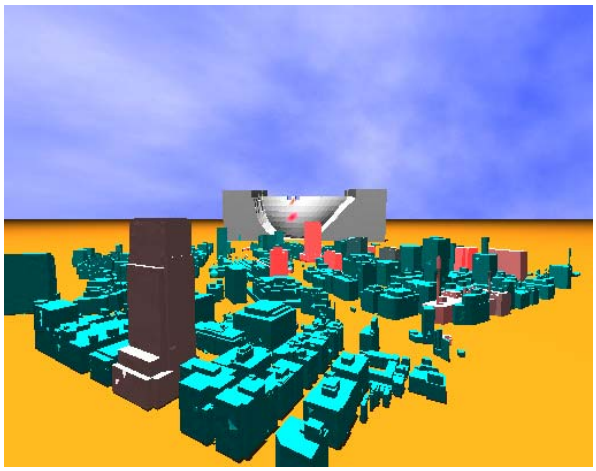

Fig. 3. Unified visualization through mediator.

6. Concluding Remarks

A new mediator is constructed for UNIVERSE, following the two strategies that are made based on the KISS principle. The performance of the new mediator is improved, regarding to scalability and modularity. With the aid of this mediator, IES is able to handle a huge amount of UNIVERSE results, in order to make the unified visualization of a virtual city which includes an arch dam in it.

References

1. M. Hori. (2006). *Introduction to Computational Earthquake Engineering*, Imperial college press.
2. C. Y. Baldwin and K. B. Clark (2000). *Deign Rules: the power of modularity* - volume 1, The MIT press.
3. Y. Ariga Study on quantitative evaluation of dynamic properties of dams by 3-D reproduction analyses, Thesis for doctorate of Saitama University, 2001.3.
4. Y. Ariga and H. Watanabe: Reproduction analysis of real behavior of existing arch dam during the 1995 hyogoken-nanbu earthquake, 13th World Conference on Earthquake Engineering, Paper No. 405, 2004.