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Enabling Technologies in the Problem Solving Environment HEDP†

Lijun Xie, Yao Zheng*, Jianjun Chen and Jianfeng Zou

Center for Engineering and Scientific Computation and School of Aeronautics and Astronautics, Zhejiang University, Zhejiang 310027, China.

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Abstract. Enabling technologies are those technologies preparing input data, analyzing output data and facilitating the whole processes for numerical simulations. This paper outlines current enabling technologies for large-scale multidisciplinary simulations used in the High End Digital Prototyping (HEDP) system, a problem solving environment equipped with capability of mesh generation and large-scale visualization. A problem solving environment is a computer system that provides all the computational facilities necessary to solve a target class of problems. Mesh generation continues to be the pacing technology for a practical numerical analysis, which is essential to yielding an accurate and efficient solution. Large-scale visualization maps the massive data to some kinds of scenes interactively, which can be realized through a tiled display wall system with distributed visualization capability. HEDP is designed for large-scale and multidisciplinary simulations, and there are four categories of modules involved, namely pre-processing module, computing module, post-processing module, and platform control module. All these modules are coupled through a software bus, which makes the modules integrated seamlessly. Detailed design principles and applications of the HEDP environment are addressed in this paper.

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1 Introduction

With the development of computational methods and computing resources, large-scale multidisciplinary simulation is becoming an important area of computations in engineer-

†Dedicated to Professor Xiantu He on the occasion of his 70th birthday.

*Corresponding author. *Email addresses:* zdxlj@zju.edu.cn (L. J. Xie), yao.zheng@zju.edu.cn (Y. Zheng), chenjj@zju.edu.cn (J. J. Chen), zoujianfeng@zju.edu.cn (J. F. Zou)

ing and science. Technologies, such as problem solving environments, mesh generation, and large-scale visualization, enable us in fulfilling large-scale simulations.

For computational simulations of various physical phenomena and processes, there is a common demand to equip the users a user interactive platform with certain capabilities, and an effective method is to construct a Problem Solving Environment (PSE) [1–4] which is a computer system that provides all the computational facilities necessary to solve a target class of problems [5]. Typically, it can reduce the difficulty of physical simulations by utilizing user natural languages and application specific terminologies, and by automating many lower level computational tasks. We define a kind of PSEs in the following formula [5, 6]:

$$\texttt{PSE}=\texttt{User interface}+\texttt{Enabling libraries and tools}\\ +\texttt{Problem solvers}+\texttt{Software bus.}$$

Commonly, a PSE should have a friendly user interface such as nature language and graphical user interface that can help the user to use the system in a direct and efficient manner. Enabling libraries and tools are the most valuable parts of a PSE. They provide all the necessary assistant functions for a simulation, such as geometric modeling, mesh generation, and scientific visualization. Problem solvers are integrated into the computational module for various problem fields. Software bus is the method to integrate all the modules to work seamlessly and efficiently.

Mesh generation continues to be the pacing technology for a practical numerical analysis and is the area where significant payoff can be realized. Furthermore, high quality meshes for encompassing special regions are essential to yielding an accurate and efficient solution. Research on mesh generation technologies is challenging, while its importance is evident [7–14]. During the past decades, both structured and unstructured meshing techniques have been extensively developed and applied to solution of various engineering problems. To deal with situations in which complex geometry imposes considerable constraints and difficulties in generating meshes, composite structured mesh schemes [15, 16] and unstructured mesh schemes currently are the two mainstream approaches.

With the increase of scales of applied engineering problems to be solved, the requirement to visualization is increasing. For large-scale problems, visualization technology is demanded to meet the requirement of large-scale numerical simulations [19], and this includes special rendering techniques, parallel processing methods [20], and distributed and collaborative visualization approaches. Large-scale visualization can be realized through a tiled display wall system with distributed visualization capability. Large scale displays provide users experience totally different from common monitors or a single projector. The benefits include showing the whole view of a large scene, offering enough area to place lots of windows at the same time for group collaborating, providing much more details of objects, and giving users immersive feeling.

The HEDP (High End Digital Prototyping) system is a problem solving environment integrating these front-end enabling technologies for high end digital prototyping. In this