

Cloud-based Modeling and Simulation Platform

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Abstract. This paper presents the construction of Modeling and Simulation (M&S) platform based on cloud computing. High performance Engineering MOdeling & Simulation (HEMOS) is an M&S software developed to support structural analysis and fluid analysis. Developed using open source software, it supports all M&S processes from pre-processing to analysis and post-processing. HEMOS is provided through HEMOS-CLOUD which was built based on Xen server with 532 CPU cores and storage of 57.5 TB. HEMOS-CLOUD consists of four hardware groups such as master, analysis, design and development for effective resource utilization and management. HEMOS-CLOUD provides job scheduling function using SGE and is developed to enable large-scale analysis by connecting with KISTI's supercomputer Tachyon2. This cloud-based M&S platform that implemented using open-source solvers and libraries can increase user accessibility and reduce production time and costs.

Keywords: HEMOS, Modeling and Simulation, Cloud Computing, Engineering Analysis

1 Introduction

Digital Manufacturing Digital manufacturing (DM) using high performance computer (HPC) and Modeling and Simulation (M&S) have been becoming the key tools that can strengthen national manufacturing competitiveness around the world. Major developed countries emphasize convergence of information and communication technology (ICT) and manufacturing, and promote various manufacturing innovation policies related to this. In particular, M&S is considered as a technology that can replace physical prototyping and experimentation with virtual product creation (modeling) and engineering analysis (simulation), which dramatically shortens the time and cost of product design and verification [1].

While the need and importance of M&S is increasingly growing, many small and medium-sized manufacturing enterprises (SME) are struggling to utilize M&S due to lack of computing resources, professional manpower, and high M&S software prices. To solve these problems, we designed and developed HEMOS-CLOUD, an cloud-based M&S platform. High performance Engineering Modeling & Simulation (HEMOS) is M&S software developed to support structural analysis and fluid analysis. HEMOS supports all M&S processes from pre-processing to analysis and

post-processing, and provides a workflow-based, easy and convenient user interface. The software also handles complex processes such as geometry simplification, mesh generation, and contact surface detection, and uses open-source solvers such as CalculiX and OpenFOAM to solve highly expensive license costs. HEMOS-CLOUD is a platform to service HEMOS and was built with a pay-per-use cloud. Section 2 of this paper introduces cloud-based M&S services. In Section 3, we discuss the detailed design and implementation results of HEMOS and HEMOS-CLOUD. Finally, Section 4 describes the conclusion and future research directions.

2 Related Works

Recently, M&S software is being transformed into a cloud-based service instead of a stand-alone service. Converting M&S software to cloud-based services can improve accessibility, reduce costs, and make better use of computing resources. Commercial cloud-based M&S services include *Simscale*, *ESI*, *Fortissimo*, and *Rescale*. *Simscale* is a cloud-based CAE platform that lets users seamlessly simulate, share and collaborate in the fields of fluid dynamics (CFD), finite element analysis (FEA) and thermodynamics [2]. *ESI* cloud offers designers and engineer cloud-based M&S solutions across physics and engineering disciplines with browser based modeling, visualization and real-time collaboration tools [3]. *Fortissimo* is a collaborative project that enables European SMEs to be more competitive globally through the use of simulation services running on a High Performance Computing cloud infrastructure [4]. *Rescale* is a cloud simulation platform that helps engineers and scientists build, compute, analyze, and scale simulations with high performance computing resources [5].

3 Design and Implementation of HEMOS-CLOUD

HEMOS is an M&S software consisting of general-purpose software that supports structural analysis and flow analysis and customized software for specific products or technology such as air cleaning, bracket, tube, and bending. HEMOS provides workflow-based step-by-step analysis processes and wizard feature to help product designers with inadequate knowledge of engineering analysis that predicts performances of designed products easily. In other words, the software provides predefined workflows according to the analysis fields and product groups that the user selected through the wizard feature. Also, it maximizes user convenience by providing an integrated user interface tightly linked with the ribbon menu, model tree, setup window, 3D view window, and workflow as shown in Fig. 1.

HEMOS-CLOUD is an cloud-based platform for servicing HEMOS software as shown in Fig. 2. HEMOS-CLOUD provides users with Windows environment and HEMOS software based on virtual desktop infrastructure (VDI) using XenServer, an open-source virtualization platform. The HEMOS-CLOUD is built with 532 CPU cores, 11,520 CUDA GPU cores, and storage of 57.5 TB and consists of four

hardware groups: master, analysis, design and development, for effective resource utilization and management. Table 1 shows the detailed specifications for each group.

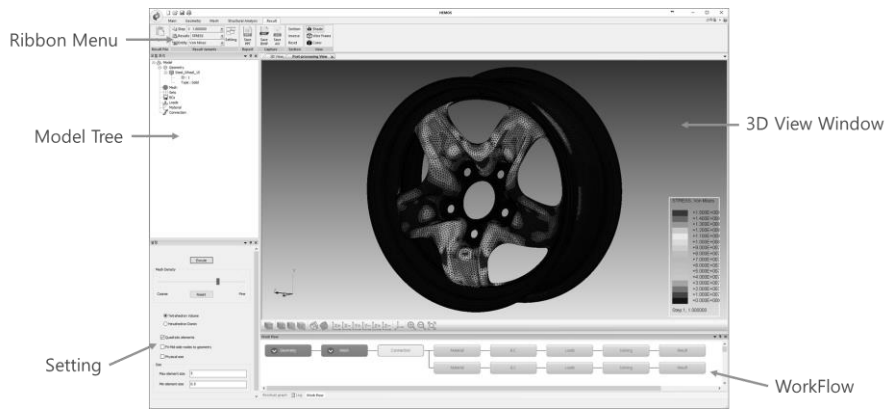


Fig. 1. HEMOS's integrated user interface including ribbon menu, model tree, setting, 3D view window, and workflow

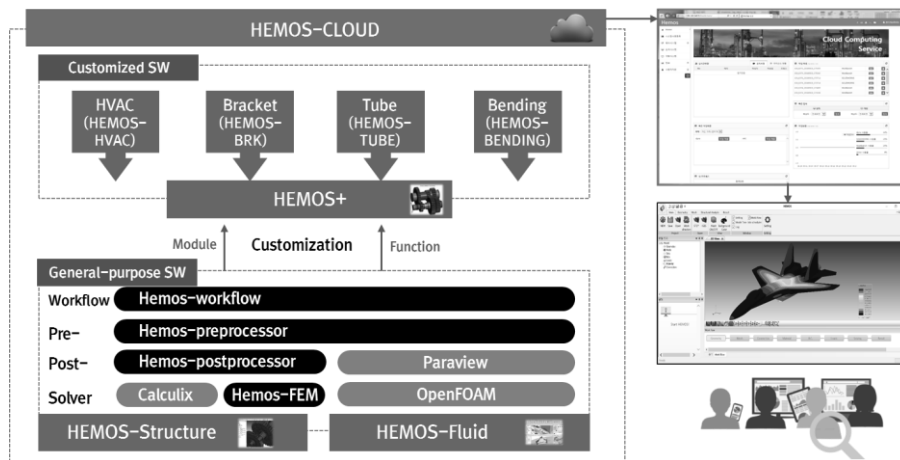


Fig. 2. Conceptual diagram of HEMOS-CLOUD

In addition to the basic resource management and monitoring, HEMOS-CLOUD provides a job scheduling function capable of dynamic allocation and load balancing of user operations using Son of Grid Engine (SGE), an open-source distributed resource management system. HEMOS-CLOUD works with KISTI's supercomputer Tachyon2 through agent-to-agent. HEMOS software users with an account can log in to Tachyon2 via One Time Password (OTP) method, and can perform HEMOS engineering analysis, upload and download data, and monitor jobs.

Table 1. Detailed Specification of HEMOS-CLOUD

Group	EA	Features	CPU Core	OS
Manager	1	- User and task management - Web-based user environment	16	RedHat Linux 6.7
	1	- File server - User accounts and directories	12	Windows 2012
Analysis	9	- Numerical analysis resources	192	RedHat Linux 6.7
Design	7	- Windows desktop environment	224	XenServer 6.2 (Windows 7)
Development	5	- Linux desktop environment - Linux development environment	88	RedHat Linux 6.7

4 Conclusion

In this paper, we describe HEMOS, an M&S software developed for designers and engineers of manufacturing SMEs, and HEMOS-CLOUD, a service platform based on cloud computing. HEMOS consists of two general purpose M&S software and four customized M&S software. The general purpose M&S software supports structural and fluid analysis whilst customized M&S software specialize in air cleaning system, bracket, tube, and bending. Particularly, we developed and applied an integrated UI using a workflow-based step-by-step method for easy and convenient use. Also, we used open-source libraries and solvers such as Open CasCade, CalculiX, OpenFOAM, and Paraveiw to develop HEMOS software without license restrictions. HEMOS-CLOUD consists of four hardware groups such as master, analysis, design and development for effective resource utilization and management as an cloud-based M&S service platform. HEMOS-CLOUD provides job scheduling function using SGE and is developed to enable large-scale analysis by communicating with KISTI's supercomputer Tachyon2. In the future, we will provide users with safe and efficient services by stabilizing HEMOS-CLOUD, expanding resources, and strengthening securities.

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