HPC Solutions for the Manufacturing Industry

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The most important requirement of a high performance computing (HPC) system, commonly known as a supercomputer, has traditionally been computational performance. Users have had to be familiar with advanced operations in order to make efficient use of high-priced and high-performance hardware. In recent years, however, there has been a shift toward low-cost HPC systems based on a general-purpose architecture such as personal computer clusters. As a result, the use of HPC systems is now spreading among users specializing in computational science research to the design and development departments in the manufacturing industry that promote virtual prototyping (simulation) to reduce development costs. These trends have generated a need for solutions that enable users to operate and manage HPC systems easily and perform design and development work efficiently. This paper explains HPC Portal, a Web-based tool for using HPC systems, System Administrator Portal, an operation and management tool, and SynfiniWay, a workflow tool. It also gives examples of solutions using these tools.

1. Introduction

Manufacturing firms hope to become more competitive by raising the efficiency of design and development work that uses computer-aided design (CAD)[1] and computer-aided engineering (CAE)[2] systems as well as by reducing costs, shortening product time-to-market, and improving product quality. Against this background, high performance computing (HPC) systems have been spreading among users in computational science research[3] to the design and development departments in the manufacturing industry. On the other hand, users who have used only Windows and the Web in the past are now confronted with the lack of skill to operate Linux (and UNIX) and the burden of administering HPC facilities in the information technology (IT) infrastructure. To solve these problems, Fujitsu has developed HPC Portal and System Administrator Portal[4] to operate and manage HPC systems easily through the Web interface.[4] Moreover, Fujitsu Systems Europe Ltd. has developed SynfiniWay[5] as a workflow tool to make design and development work on HPC systems more efficient. This paper explains application examples of solutions that use these tools for manufacturing firms.

2. HPC Portal to support CAE users

This section introduces examples to help CAE users to perform analyses with the simple graphical user interfaces (GUIs) provided by HPC Portal.

2.1 Functions

HPC Portal is a tool that enables end users to use heterogeneous HPC systems from a Web browser in a common and easy way. In addition to basic functions like file operation, compil-

ing and linking, job submission, status display, and batch job deletion, HPC Portal provides a function that makes it easy to customize a GUI specific to simulation work in design and development (customization of application GUI). Some typical screenshots of HPC Portal are shown in **Figure 1**.

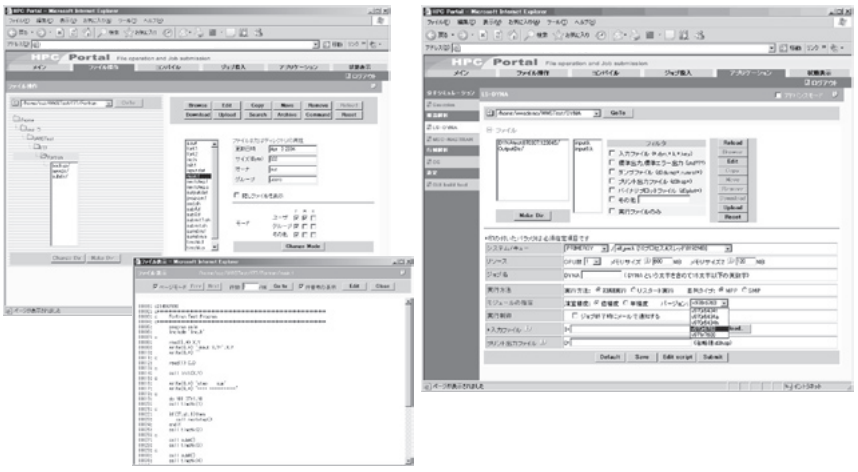
2.2 Customization functions

Considering that system configuration and operating policies differ from one customer to another, a fixed GUI would satisfy the needs of few customers. HPC Portal has a function that enables the GUI to be easily customized by a definition file or template file, so it can support various types of computer equipment and accommodate changes in operating policy such as queue classes. Furthermore, with this "application GUI customization" function, HPC Portal provides the following functions to simplify the creation of a job-execution GUI specific to simulation work:

1) Simple GUI creation by using a definition file
2) Advanced GUI creation by using a Perl script

The simple GUI creation function can generate user-unique parameter-input forms automatically just by specifying component types (text boxes, pull-down menus, etc.) and menu selection values in a simple definition file. The advanced function enables end users to code parameter-input forms by using a Perl script. This lets them create a GUI more freely than the simple GUI creation function. Although this method requires programming skill, it is much less expensive than developing an entire Web application because end users only need to create parameter-input forms. The concept behind the customization of application GUIs and an example of GUI creation are shown in **Figure 2**.

In addition, the base software called POESY behind HPC Portal and System Administrator Portal (described later) acts as a content management system[6] that simplifies the creation of portals for various purposes. It can be used to edit menus and create Web pages by simple scripting rules that do not require any HTML statements. In short, POESY is not limited to creating job-execution GUIs—end users can easily add pages, including user guide and



(a) File operation

(b) Customization of application GUI (Example of LS-DYNA)

Figure 1
Screenshots of HPC Portal.

operating-schedule announcements to menus to create and provide CAE support portals that are even easier to use.

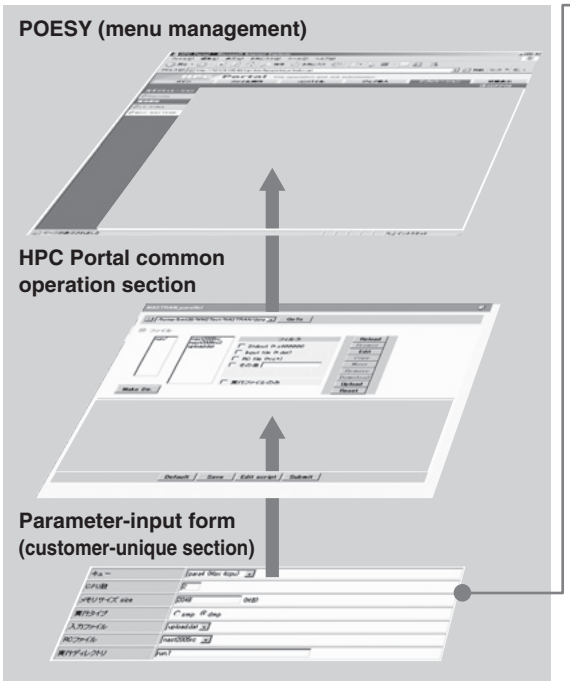
2.3 Effects of introduction

1) CAE support by simple GUIs

Targeting two computer centers that have installed the HPC Portal tool, we investigated whether users selected the conventional way of Linux (and UNIX) (i.e., login by ssh) or HPC Portal. Both centers are in manufacturing industries that promote CAE. We found that the number of users logging in from HPC Portal was greater than that from ssh at both centers. We then compared the HPC Portal usage frequency between the two centers, and we found that the center with more GUIs created by the application GUI customization function had a higher HPC Portal usage frequency. This shows that simple and efficient GUIs created by HPC Portal can expand the use of HPC systems even among users unfamiliar with Linux (and UNIX) and promote the use of CAE by providing job-execution GUIs for commonly used CAE applications.

2) Pre/post menus to make simulation work efficient

In addition to job-execution, the application GUI customization function can be adopted to support the preparation of input data (pre-processing) and the preparation of graphs and other graphic media for visualizing results (post-processing). POESY, meanwhile, can be used to automatically generate result reports that include simulation parameters and image files for visualizing results and to enable information to be shared among people engaged in design and development through the Web. For end users who need pre/post processes, we can create simulation portals that include menus for the "pre-solver-post" sequential processes. These portals help to make simulation work more efficient and simplify information sharing.



Parameter-input-form creation methods

(1) GUI creation by definition file requiring no programming

(2) Advanced GUI creation by Perl script

Example of creating a simulation-application GUI

Structure/collision	LS-DYNA
	ABAQUS
	ADINA
	Nastran
Fluids	FLUENT
	STAR-CD
Molecules	Gaussian
	Amber
	MS Discover, DMol3
Electromagnetism	Poynting
	ACCUFIELD
Other	In-house application

Figure 2
Application GUI customization function.

3. Management load reduction by System Administrator Portal

This section explains examples of how System Administrator Portal can support the monitoring and management of HPC systems.

3.1 Functions

System Administrator Portal is a tool that enables system administrators to monitor and manage a heterogeneous system composed of different types of computer equipment using a uniform view from a Web browser. It provides functions for displaying running status, managing power supplies, displaying CPU and memory utilization rates, displaying disk utilization rates, managing users, and retrieving job logs. It consists of base software called POESY plus tools for collecting information targeted for monitoring and a group of modules for converting collected information into graphical output included on POESY pages. Here, OS commands (ping, sar, and free) are used to collect necessary information as well as middleware (power-supply management and job scheduler) provided by individual vendors. RRDtool freeware[7] is used to create historical utilization graphs. Some screenshots of System Administrator Portal are shown in **Figure 3**.

3.2 Customization functions

Monitoring and management targets in a system differ from one customer to another, and there are various needs in terms of Web menus and screen layout. The display modules making up System Administrator Portal display only monitoring information and operation GUIs and do not display entire Web pages. It is the role of POESY to lay out entire pages and embed those display modules in pages. As shown in **Figure 4**, this embedding can be defined by simple scripting rules. In short, each display module may be coded for a specific function, so it helps to save development and maintenance costs.

3.3 Effects of System Administrator Portal

1) Intuitive understanding of conditions in monitoring functions

In System Administrator Portal, the node running-status displays and trouble-status displays linked with the E-mail notification function described later are useful for enabling a system administrator to comprehend problem conditions at a glance. In addition, the historical graphs showing CPU/memory utilization rates and disk utilization rates display changes

(a) Display of running status

(b) Display of CPU/memory utilization rate (history)

Figure 3
Screenshots of System Administrator Portal.

in system usage quantitatively. This can provide a system administrator with reference data for optimizing IT-infrastructure investment planning and operation design.

2) Simple operation and management operations

From a company's point of view, the costs involved in training the personnel needed for operating and managing a system and the cost of system operation are major issues in addition to the cost of deploying an IT infrastructure. The straightforward GUIs provided by System Administrator Portal for system power on and off, operation schedule setting, user registration, etc. require no advanced skills on the part of the operator. Moreover, the ability to handle different computer equipment with a set of common operations in System Administrator Portal helps to reduce the cost of training system administrators and lower the system operation load on those administrators.

3) E-mail notification function

System Administrator Portal includes an E-mail notification function for enabling a speedy response to faults that occur in the target system. While the remote notification function provided by the SupportDesk maintenance service provided by Fujitsu targets hardware fault indications and abnormalities and operating system crashes, System Administrator Portal can monitor various services (ssh, NFS, license management, etc.) that can affect operation as well as the amount of disk usage and other characteristics. This makes it possible to respond quickly to service abnormalities and to problems originating in the environment that are generally difficult to notice, thereby contributing to early system restoration and improved system availability ratio.

4. SynfiniWay

This section introduces effective utilization of computing resource and efficiency of design and development work by SynfiniWay.

4.1 Functions

SynfiniWay is a tool that enables individual simulation processes that span a distributed computer environment (distributed computing resources) to be defined as services, and it enables those services to be combined as needed to construct optimal workflows for a customer's design and development work. Installed as

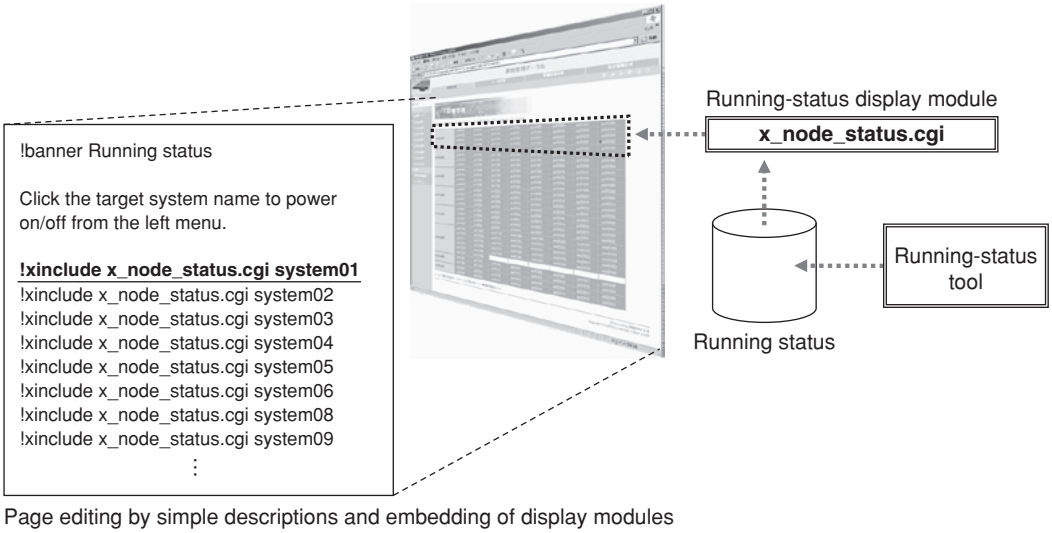


Figure 4
Embedding of display modules in System Administrator Portal.

dedicated client software on a user's personal computer, it provides GUIs for inputting workflow and simulation parameters, and it includes a function for automatically transferring simulation input data prepared at the user's personal computer to the most appropriate computer.

4.2 Global scaling

As globalization continues to progress in the manufacturing industry, manufacturing firms must be able to use computing resources spread across multiple sites and organizations more effectively if they are to be more flexible and global in their operations. That is, the global scaling of design and development work must be thought of as an essential element to enhancing the competitive and collaborative abilities of an organization (**Figure 5**).[8)-12)] The ultimate objective of SynfiniWay is to provide a service-oriented IT infrastructure and achieve global scaling in the design and development work of customers involved in the manufacturing industry.

4.3 Service-oriented approach

Although the Service Oriented Architecture (SOA) has been receiving much attention as the newest trend in the world of IT, there are still many aspects of the manufacturing industry that have yet to be automated when designing and developing products using IT (such as complicated scripts for otherwise well designed processes in which the order of execution may go forward or backward by jumping steps, the manual transfer of data, etc). This is due to a lack of middleware with specifications that are robust against the demands of diverse production lines. SynfiniWay is designed to treat individual tasks in any kind of work as services.

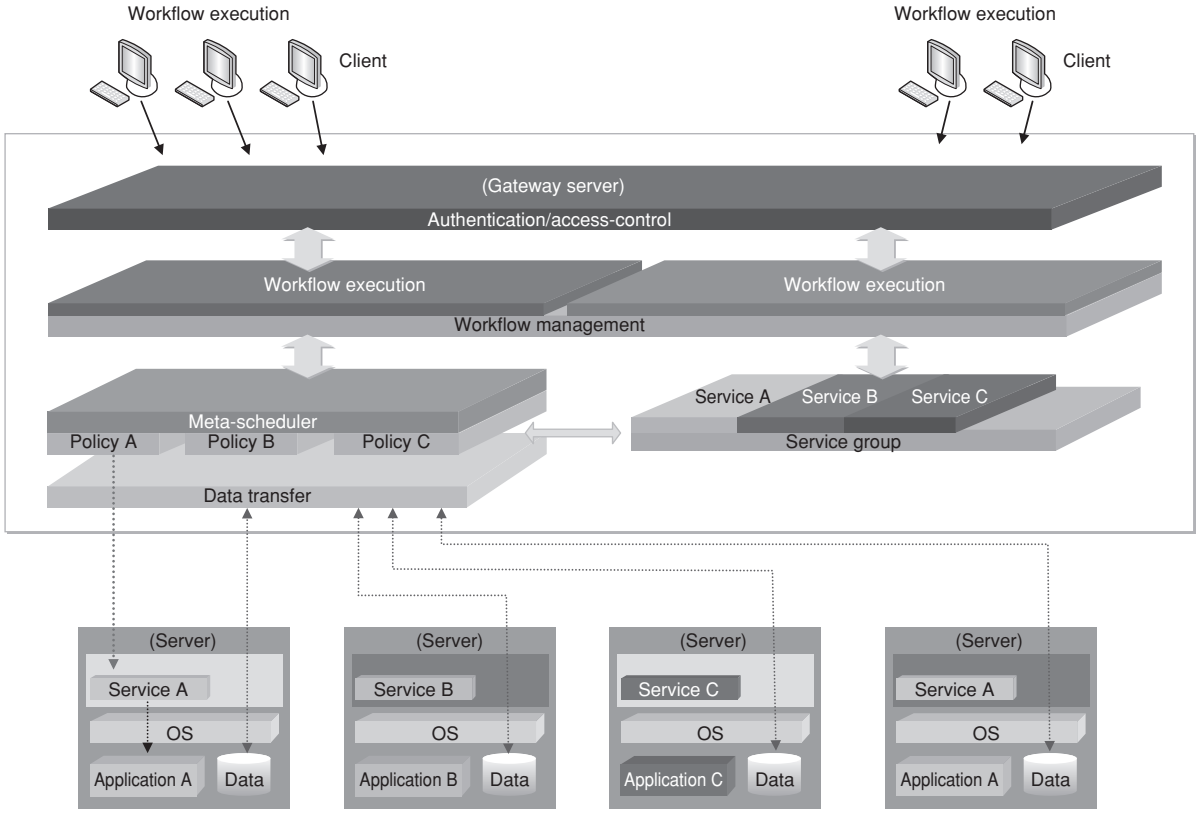


Figure 5
Architecture of SynfiniWay.

4.4 Framework

The SynfiniWay framework hides the physical location of computing resources and provides available resources in a virtual manner (**Figure 6**). One reason for this approach is that users simply have no need to recognize the location of computing resources, but another is to improve security by avoiding the way in which users log in directly to computers by ssh, telnet, and other commands in order to work. SynfiniWay also enables users to concentrate on design and development work, as it were, their primary objective, because it eliminates the need to acquire specialized IT knowledge such as Linux (and UNIX) operating methods, script-writing methods, and application-specific usage methods.

Introducing a service-oriented IT system enables users to construct reusable and independent design and development workflows that are separated from the IT infrastructure layer. With a design built upon the ability to use computing resources located anywhere within the SynfiniWay framework, SynfiniWay enables specialized technology in a firm's work to be developed and circulated throughout the organization. Some customers have recently demonstrated how SynfiniWay can be used to incorporate computer systems of outside institutions within a firm's existing IT framework to

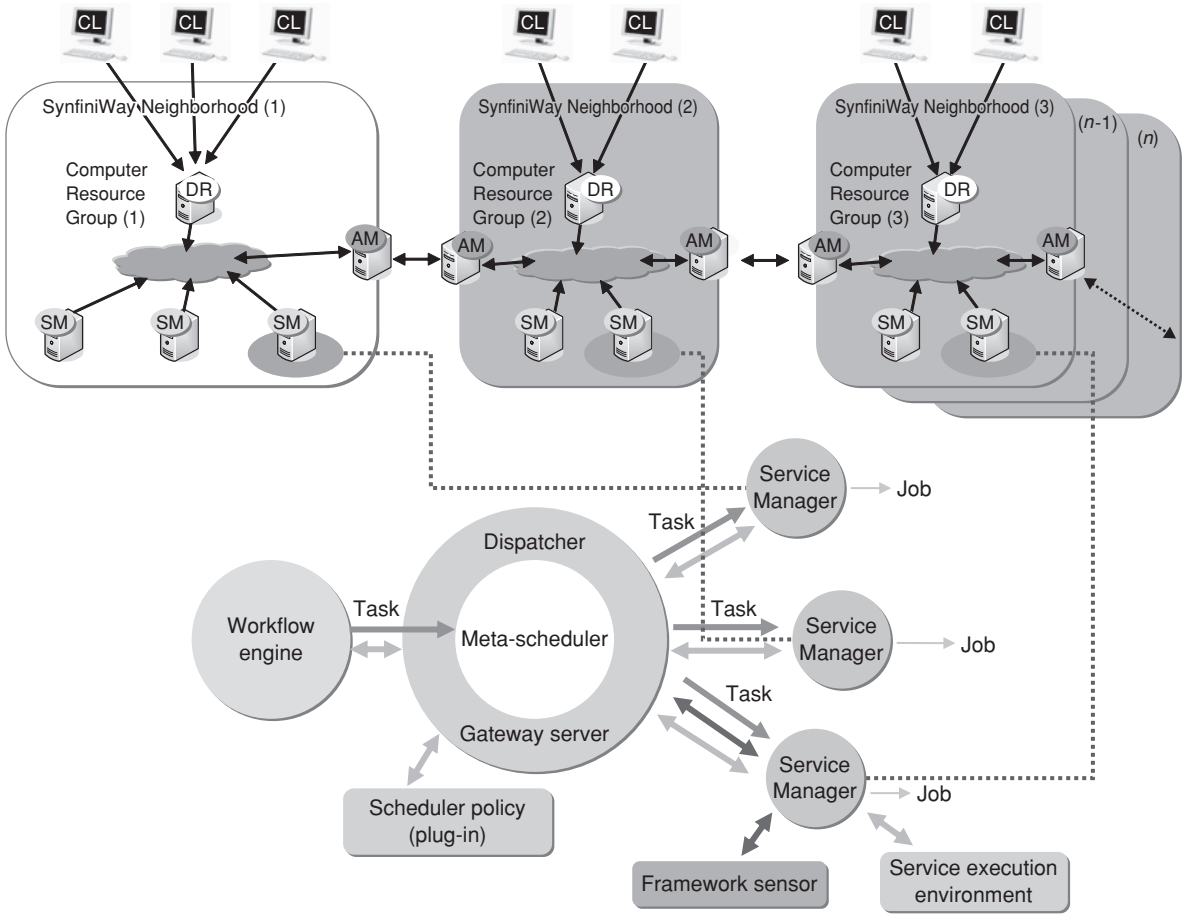


Figure 6
Computer resource allocation and meta-scheduling in SynfiniWay.

cope with peak load times in computer usage.

4.5 Workflow and file transfer

The idea behind SynfiniWay's workflow is based on Workflow Management Coalition (WfMC) V1.0 specifications.[13] A workflow is a set of tasks linked by sequence, branching, and repetition. Here, files that are needed by a service called from within a workflow are automatically transferred to the computer executing that service so that the user is freed from the work of executing file transfers. This file transfer function in SynfiniWay transfers files to a target computer in the shortest possible time. By reconfiguring and managing design and development work performed in a heterogeneous and distributed computer environment in the form of services, SynfiniWay enables work and IT management to be completely separated.

4.6 Workflow/task meta-scheduling

To use registered computing resources in the most effective way, SynfiniWay provides a meta-scheduling function. The optimal use of computing resources expedites computational results and minimizes wasted time (Figure 6). In meta-scheduling, a component of SynfiniWay called the Service Manager decides when a task should be executed. To manage a framework spread across the globe, the meta-scheduling function includes a function for harmonizing task execution between executing workflows. For the future, the plan is to extend SynfiniWay functions such as by adding an execution function that considers priority among different workflows and tasks and a sensor function that provides various types of usage information through the incorporation of framework sensors.

5. Conclusion

This paper described the features of tools developed by Fujitsu and Fujitsu Systems Europe Ltd. for use with HPC systems and introduced examples of solutions using those tools. The use of IT for virtual prototyping (simulation) of products in design and development departments in the manufacturing industry can be expected to accelerate from here on. In addition to providing HPC infrastructures, Fujitsu and Fujitsu Systems Europe Ltd. plan to develop tools and solutions that will promote further use of HPC in design and development work, enhance security, improve usability, reduce operating costs, and awaken business potential.

Finally, we would like to extend our deep appreciation to our many customers for their gracious opinions and comments on Fujitsu's expansion to tool development and the solutions business.

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