Fujitsu’s Engineering Cloud

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Product design is currently facing some issues: higher development costs, increasingly complex products, a faster time to market, cooperation between enterprises, and business continuity including measures to deal with natural calamities. To solve these issues, it is important to have simulations, information sharing and use, and linkage between tools and sections. Of course, greater effects can be obtained by having deep mutual cooperation between them. For example, electrostatic or thermal fluid simulations are performed in order to detect at an early stage of design the possibility of a device being damaged by the heat generated within it or electrostatic discharge. However, in the distributed design environment, information on housing and printed circuit board design is collected and then work begins to transfer this information to the simulation environment. This gives rise to the issues of the effort needed to copy information and information management (security). To solve them, Fujitsu thinks that by shifting the engineering design environment to the cloud, the speed of simulations, information sharing and use and linkage between tools and sections will be enhanced. It believes this will achieve product design that has a high design quality. This paper focuses on the issues in product development. As an approach to solving them, it introduces Fujitsu’s Engineering Cloud, a tool that Fujitsu is working on now.

1. Introduction

Product design in the manufacturing industry is currently facing some issues: higher development costs, increasingly complex products, a faster time to market, cooperation between enterprises, and business continuity including measures to deal with natural calamities.

To solve these issues, it is important to have simulations, information sharing and use, and linkage between tools and sections. Naturally, these can produce greater effects by deep mutual cooperation (**Figure 1**).

For example, simulations are performed in order to detect at an early stage of design the possibility of damage to a device in a product equipped with a high-performance LSI caused by heat generated in equipment or electrostatic discharge. As preparation for the simulations, data obtained by 3D conversion of printed circuit board (PCB) CAD data and 3D housing design data are integrated for modeling the entire equipment, and then thermal fluid and electrostatic simulations are carried out. For smooth implementation of this design process, it is important to have an efficient design and analysis environment and inter-section cooperation.

Simulations can be made full use of to reduce the amount of design rework by analyzing individual PCBs and the entire equipment, scale up a model accompanied by fine meshing so as to improve the analysis accuracy and cooperation, and carry out coupling simulations to give the design total optimization. To that end, an environment that integrates all design information is important.

To address these issues, Fujitsu thinks that shifting the engineering design environment to the cloud can enhance the speed of simulations, information sharing and use, and linkage between tools and sections, thereby realizing manufacturing with high design quality.[1)]

With the focus on the issues in product development, this paper introduces Engineering Cloud, on which Fujitsu is currently working, as an approach to solving those issues.

2. Overview of Engineering Cloud

In this section, we describe peculiarities of the field of engineering and present new technologies and environments required for the provision of Engineering Cloud services.

2.1 Peculiarities of field of engineering

1) Diversity of design tools

For product development, the design work of individual electronic components that constitute equipment such as ASICs, FPGAs and PCBs is allotted to specialized engineers. The engineers in charge select various design techniques, CAD types and simulation tools ranging from cutting-edge technologies to general-purpose technologies that are suitable for what they need to design.

While Fujitsu has been striving for and promoting the standardization of design environments, 200 or more types of tools are used. The diversity of these tools (commercially available or internally produced software) gives rise to the need for different OS environments including Windows, Linux and Solaris, appropriate use of 32-bit and 64-bit OSes and large-scale analysis environments (PC clusters and massively parallel computers) specific to simulation and verification tools. Some tools requiring a memory size of 64 Gbytes or larger may be used in large-scale design and verification and the memory size is on an increasing trend in line with device scale-up.

In short, the field of engineering requires a heterogeneous computer environment and continuous investment of resources to achieve improved performance and scale-up for the purpose of product development, which undergoes rapid technological changes to meet

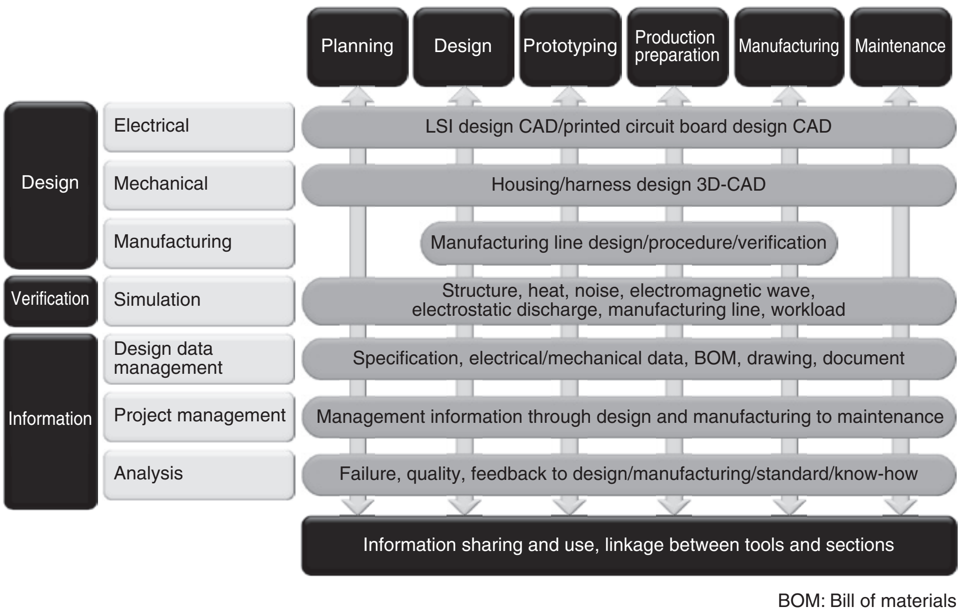


Figure 1
Overviw of Fujitsu's manufacturing.

customer demands.

2) Interactive design requiring high-speed response

As represented by 3D-CAD, a designer uses a high-resolution display to check the details of design and operates a mouse and keyboard to repeatedly improve the design. This interactive design (between the computer and designer) requires processing capacity and display performance that offer high-speed response.

The above-mentioned design of electronic components and mechanical design always include interactive design in the design process, which serves as an important design technique for enhancing product quality and performance.

3) Workstation terminals used by engineers

Interactive design has historically required high-performance workstations (WSs). WS terminals, which are equipped with a high-performance graphic board and high-capacity memory for high-speed (3D) image processing and have installed design tools (3D-CAD, etc.) used by engineers, are very expensive. For that reason, the design environment has required a WS to be shared by more than one engineer.

2.2 Structure of Engineering Cloud

This subsection describes the requirements and technologies necessary for consolidating all of the existing design environments from expensive WS terminals under distributed management at design bases to the cloud environment.

1) Basic requirements of Engineering Cloud

- A design environment required for product development is built in the cloud
- All applications (for CAD and simulations) are run on servers in the cloud
- The results of processing (information on the screen) are transferred from a server to a designer's terminal
- A designer's terminal is used simply to view the screen showing the results of processing and a PC for OA operations can be used for design

2) Computer environment in the cloud

A heterogeneous design environment required by design tools used for product development is put in place in the cloud.

- Applications required by designers
- OSes and computers on which the respective applications run
  (Windows, Linux, Solaris, 32-bit OS, 64-bit OS, PC cluster, grid computing, massively parallel computer, computer with larger than 64 Gbyte memory)
- Storage for storing design data, documents and results of design processing (all information managed in the cloud)
- Server equipped with GPU for graphic processing and high-speed parallel operation processing

That is, the resources that were conventionally invested in and managed at design bases are centrally managed by consolidating the design tools (licenses), processing servers (including GPUs for graphic processing) and storage in the cloud. This leads to a reduction of TCO at the design bases.

3) Innovation of client terminals

WSs, which were under shared management and use at design bases, become unnecessary and low power consumption PCs for OA can be introduced for mixed use. In addition, any environment with a network connection to the Engineering Cloud allows engineers to view the design and alter it regardless of their location and taking advantage of the cloud environment provides flexibility to support the changing work styles.

2.3 High-speed image display technology

Because a wide variety of design tools are used in the field of product development, we developed a high-speed image display technology with a policy of eliminating the need for special embedding into the individual tools and the need for introducing exclusive devices on cloud servers and terminals.

1) Basic overview

The processing that was conventionally performed by a client terminal has been functionally divided between the server and the terminal. For the terminal, in particular, the function has been concentrated into the decompression of compressed data sent from the server to be shown on the display in order to reduce the load.

Accordingly, the client terminal does not require an extension board (with a GPU) exclusively for graphic processing or a CPU with high processing capacity and only needs memory of a size for office processing, which has now allowed a PC for OA operations to perform operations that were conventionally carried out by a WS terminal.

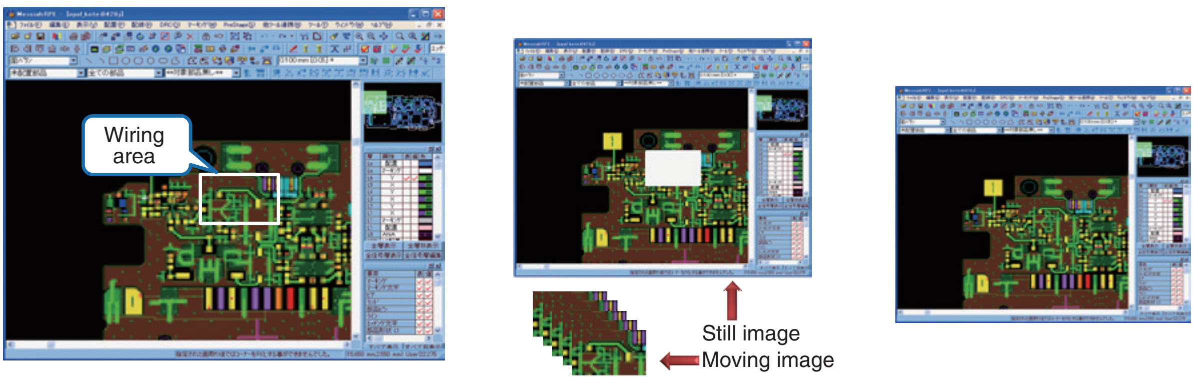
2) Fujitsu's proprietary high-speed display technology: Remote Virtual Environment Computing (RVEC)

On the premise that a few thousand designers of the Fujitsu Group engage in design work in the same way as in the past in a cloud environment (using the existing network), Fujitsu Laboratories has developed and commercialized technology with the goal of minimizing the bandwidth used and achieving a smooth display processing speed. Here we present the technology for minimizing the bandwidth used, part of RVEC, a high-speed display technology that has been developed.

The simple method in which an entire on-screen display processed by the server is compressed and sent as a moving image causes the existing network capacity to be exceeded. To address this issue, we devised a new way (Fujitsu's proprietary way) of hybrid processing a still image and moving image regions. In interactive design processing, regions are distinguished between those with little view change such as a menu bar and those with significant view change centered on the mouse pointer; the former are processed as still images and the latter as moving images.

In this processing on the server, the screen is divided into multiple blocks, each of which is monitored for view change, and still image processing and moving image processing take place in temporal units for compressing and encrypting the transfer data to send to the terminal. The terminal sequentially decompresses the data, combines the still and moving images, and performs display processing (**Figure 2**).

This method has achieved a significant reduction in the bandwidth used (to about one-tenth as compared with the simple moving image transfer).



(a) Preparation for sending view on server

(b) Distinction of moving image regions on server

(c) Client view after decompression

Figure 2
Hybrid processing of moving and stll images.

3) Distribution of response time

Response time (from client terminal command selection to regeneration) with RVEC used is the sum total of 1 through 5 in **Figure 3**.

Generally, a response time that offers stress-free operation to designers is reported to be 150 ms[2] and this value has been used as a rough standard for evaluation. There may be a slight difference in judgment depending on the designer and the level of skill.

We have assumed that Engineering Cloud servers are installed in the Kanto region (the eastern region of Japan's main island), the stress-free response time is 150 ms, and the service area is the whole of Japan. Then, the distribution of response time is estimated to be approximately 50 ms for network delay and 100 ms for other processing steps. To meet this numerical target, we have worked on enhancing the performance of RVEC and improving the processing speed of Fujitsu's internal tools, and we were able to successfully develop a stress-free cloud environment.

Future advancement of technologies may open up a path to faster networks, a greater amount of available bandwidth and enhanced performance of CPUs/GPUs. This will expand the scope of application of freedom from stress and give rise to expectations for the development of services such as a global design environment and sharing of design information.

3. Fujitsu's approach to Engineering Cloud

Activities intended for the shift to cloud in the field of engineering of the Fujitsu Group were classified into "license consolidation and server consolidation (internal ASP)" and "development into Engineering Cloud" for implementation.

The following subsections describe the activities.

3.1 License consolidation and server consolidation (2000–)

The introduction of commercially-available CAD tools started in the 1980s and designers in the respective sections also took charge of license management, installation and management

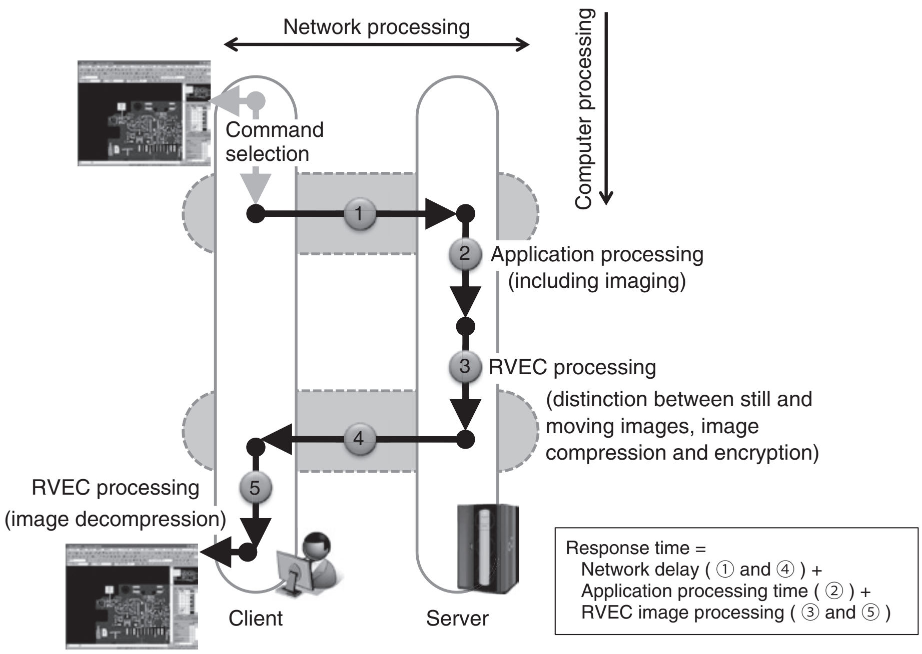


Figure 3
Components of response time.

of execution servers and regular update management.

At that time in 2000, there were many issues to address including the greater number of types of licenses owned, increased person-hours for their management and a low operating rate. To solve those issues, an internal ASP was set up for gradually moving ahead with license consolidation and server consolidation. We made a start on electrical CAD and expanded the scope to include the CAE system and further to 3D-CAD.

1) Enhancement of simulation environment

In the process of sharing computer resources, we enhanced the integrated design environment in response to the need for a concurrent processing environment for a few thousand to a few tens of thousands of jobs (grid computing) and a parallel processing environment for large-scale simulations (PC cluster), which are required in the field of design optimization simulation.

2) Strengthening of governance and improvement of operation efficiency

We work on the normalization (standardization) of tools introduced by the respective sections and cooperate with the sections concerned in an effort to dispose of unnecessary licenses and maintain and improve a high operating rate.

3.2 Development into Engineering Cloud (2010–)

The internal ASP became established internally in Fujitsu but design data in the product development phase were still distributed in the design section. We thought that a design environment allowing efficient implementation of simulations (thermal fluid, electromagnetic field, etc.) of entire equipment including the housing together with analysis of the results and design process of feedback to product design would be even more important and worked on the development into Engineering Cloud.

When design data are distributed within the design section, design data copying is necessary for each design process such as linking between electrical CAD and mechanical CAD, modeling and simulation, and this poses challenges in areas including design efficiency and security. As a measure to address these challenges, we launched Engineering Cloud for the purpose of achieving integrated design, in which design data and documents (specifications) are centrally managed in an integrated environment and the entire design work can be completed within the environment.

The following describes the system configuration of Engineering Cloud.

Fujitsu uses one integrated design and development environment known as Flexible Technical Computing Platform (FTCP) for the design of products ranging from mobile phones to supercomputers. We migrated this FTCP from the internal ASP to a cloud environment. Major features include:

1) Environment allowing the utilization of internal and external resources for large-scale simulations
2) User authentication/license management system
3) Secure design data management
4) RVEC high-speed display technology for sending process views to designers' terminals
5) Provision of GPU-equipped servers capable of high-speed image processing

We intend to make use of this Engineering Cloud design environment to support the increasingly sophisticated design techniques and future work styles (**Figure 4**).[3)]

4. Benefits of introduction of cloud

The following describes the benefits of introducing cloud (including future approaches) (**Figure 5**).

1) Availability of a uniform environment to

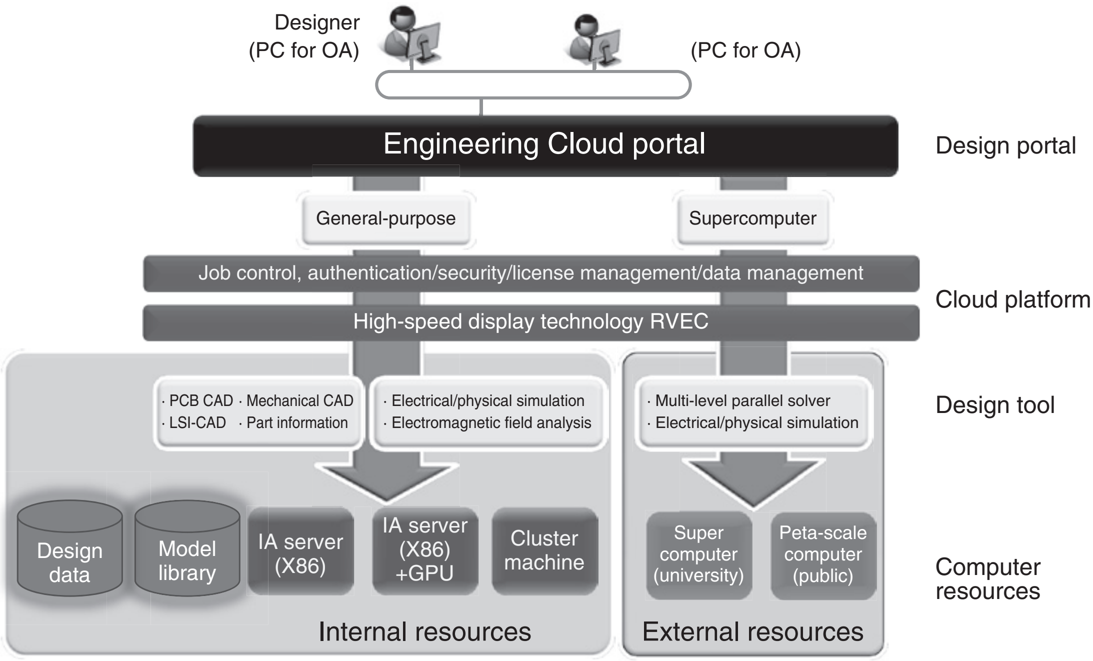


Figure 4
Engineering Cloud system configuration.

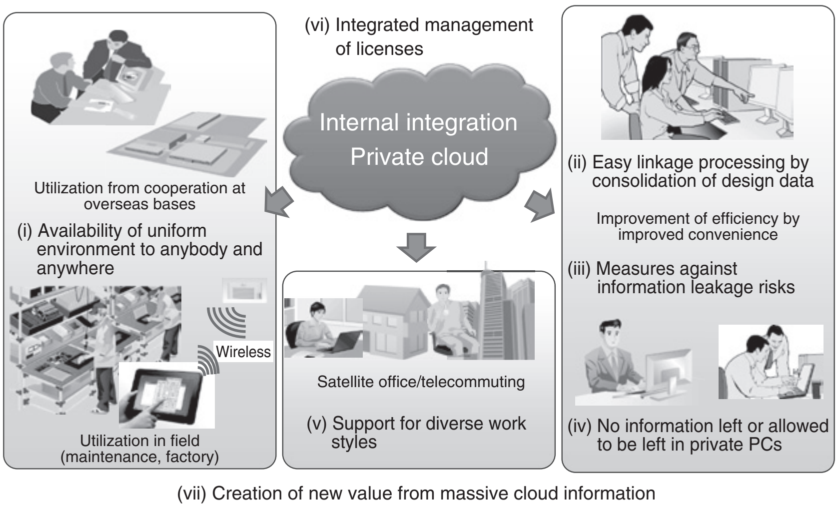


Figure 5
Benefits of introducing cloud.

anybody and anywhere

- Viewing and correction of design information from business trip locations in Japan and overseas
- Immediate resumption of design (business continuity)
- Design started on the day of the launch of a new project (conventional preparation time of two weeks reduced to a few hours)
- Reduction of power consumption (from high-performance WSs to PCs for OA)

2) Ease of linkage processing by consolidation of design data

Data are loaded within a data center (LAN) in Engineering Cloud without using the internal network (WAN) and the processing is promptly performed.

3) Measures against information leakage risks
- Measures taken against information leakage of design data, a lifeline of an enterprise
- Design data not taken out of the company or overseas

4) No information left or allowed to be left in private PCs
- Design environment built on a cloud, serving as a measure against the risk of loss
- Work resumed immediately with another PC in the event of PC failure

5) Support for diverse work styles
- Cooperation across enterprise borders and large-scale multi-site development (management/operation and sharing of design information with the cloud)
- Telecommuting required because of family circumstances (childcare, nursing)
- Viewing of information via tablet PCs or smartphones (used for reform of operations such as sales, repair and design review)

6) Realization of integrated management of licenses
- Benefits of license sharing

Migration of an application execution environment into the cloud makes centralized management of licenses easier than in the conventional distributed design environment. In one case within Fujitsu, consolidation and sharing of licenses has proved to produce a cost reduction effect of 30 to 40%. The reduced cost is invested in enhancing IT (purchasing new and advanced simulations to strengthen design verification, for example) so as to improve the design quality and reduce the design period.

- Consolidation of license management servers

Centralizing the license management operations of the individual sections brings about a significant effect in the reduction of management person-hours. At Fujitsu, management was performed respectively by 11 sections before the integration, and this has now been consolidated into one section.

This license server operation and management include server OS update, response to application failure and system update and normal operation confirmation of an enhanced version. Before the integration, engineers took charge of these operations between their design tasks at the respective design bases.

7) Creation of new value from massive cloud information

For operation of Fujitsu's internal tools, information was collected, analyzed and used in many ways as in the service of real-time collection of CAD operation logs of all designers. There was direct contact by the CAD support personnel to any designer with a failure and a trend survey on the frequency of use of CAD functions and degree of design difficulty (signal frequency, design period, etc.) was conducted, and the results fed back to the fields of development and support. Along with the progress of the shift to cloud, even more massive and extensive information is accumulated in the cloud. We are considering using it to create new value and offering information that can be used to help people make decisions in various activities ranging from design through production to maintenance and estimation processing.

For example, new knowledge (on design technology and on manufacturing or production engineering) based on the correlation between design information and manufacturing or production information (design, manufacturing, field quality) can be created and fed back to the respective fields, which brings about expectations for an even greater effect.

5. Conclusion

This paper has presented the Fujitsu Group's approach to migrating a design environment to the cloud in product development.

The current challenges include support for

GPU virtualization and load adjustment so as to relieve operators of stress.

For this new approach that relocates GPUs, which were traditionally mounted on client terminals, onto the server and efficiently uses GPUs in virtual environment, environmental preparation and commercialization is taking time.

Regarding application within Fujitsu, we are promoting Engineering Cloud on the premise that the existing network environment will be used. We think an important challenge is developing technology that will allow the system to self-diagnose the optimum load adjustment according to the bandwidth of design bases, number of designers and amount of operations to relieve operator stress and conduct automatic adjustment.

From now on, we aim to help people use the cloud to expand services across national borders and allow them to connect with others as a way of providing opportunities for cooperation across enterprise borders. To that end, we intend to continue to enhance the Engineering Cloud environment equipped with flexible and open connectivity based on the cloud platform that makes use of standard technologies.

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Mr. Yasuda is currently engaged mainly in supervision of engineering cloud projects.