Mechanical Design Platform on Engineering Cloud

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The Fujitsu Group is always using leading-edge information and communications technology (ICT) and building an integrated design environment that is important for product design. Engineering Cloud is part of that process. It consists of many software and hardware components. In this paper, we concentrate on the mechanical design platform software in Engineering Cloud that is used particularly in product development. This mechanical design platform software is based on virtual product simulator (VPS) technology. VPS technology allows the user to quickly and easily use 3D data throughout the overall life cycle of a product. The platform combines the equivalent functions of conventional VPS and the functions necessary for preprocessing and postprocessing in the analysis and simulation fields. This paper introduces the platform's concept and its basic configuration. Then it describes the benefits that can be obtained by using a platform on Engineering Cloud and the future issues. It does this from the three viewpoints of resources for use in calculations, handling large amounts of data, and resources for use in visualization.

1. Introduction

In the world of information and communications technology (ICT), the toing and froing between centralization and distribution of hardware resources is repeated in terms of its operation. Network bandwidth costs have become extremely low in recent years and we encounter increasingly often the term "cloud computing," which indicates the arrival of a new centralization age. While this term represents a comprehensive concept, it is positioned in this paper as an "ICT infrastructure that creates value when used to build new businesses and services with customers"[1] from the perspective of service, rather than that of technology. Engineering Cloud mentioned in this paper (see "Construction of Integrated Design Development Environment and Its Deployment on Cloud" contained in this magazine) is one example.

Cloud computing is often classified from the viewpoint of service provision into IaaS, PaaS and SaaS or by implementation model into public cloud and private cloud. In this paper, it is seen in terms of whether it is for general or specific purposes. This paper focuses on the latest state of the mechanical design platform software, which is a component of development environment in Engineering Cloud for specific purposes. It describes the configuration and characteristics based on the virtual product simulator (VPS)[2] technology, which is central to the mechanical design platform, and the benefits and future issues from the viewpoints of resources for use in calculations, handling large amounts of data and resources for use in visualization.

For the overall product development environment of Fujitsu, see the released reports.[3),4)]

2. Engineering Cloud and mechanical design platform

Figure 1 shows the structural concept of the development environment in Engineering Cloud.

Fujitsu has been working on developing an environment that allows various types of verification to be conducted in the overall product lifecycle by taking advantage of various CAD and analysis tools in product development to minimize prototyping and using virtual prototypes in the upstream of the development process as much as possible. Since 2006, we have been consolidating computer resources to operate an environment capable of performing parallel computations using Linux servers and PC clusters with high-capacity memory. This has made it possible to conduct large computations for structural and thermal fluid analyses. Analysis from microscopic to equipment levels can be conducted and it is now possible to identify technical problems in advance and assess application technologies in the early stages. For different examples of analysis, please refer to "Structural and Thermal Fluid Simulation and CAD System Linking" contained in this magazine.

Meanwhile, it cannot be denied that the increase in scale and complexity of design platforms has inconvenienced many people because they have to make use of various verification tools. To address this problem, we have been engaged in placing various tools onto a platform.

We used VPS as the technological base of the mechanical design platform. VPS has been provided to users inside and outside the company and received favorably as a user-friendly tool that allows mechanical 3D data, which are considered "heavy," to be used quickly and intuitively over the entire lifecycle of a product.

"Heavy" tools of another representative type are those for analysis and simulation. Designers who perform analysis and analysis specialists optimize or mesh 3D data to process them into data suitable for analysis computation. After this, they perform computation processes and verify massive result data. They make use of the so-called "pre/solver/post" (preprocessing, analysis execution and postprocessing) tools to work on problem solving. Although evolution of the ICT infrastructure is making it possible to perform large-scale analyses in practical periods of time, they still require various types of preprocessing and postprocessing. We use the VPS technology in this field as well to build a mechanical design platform that pursues higher convenience.

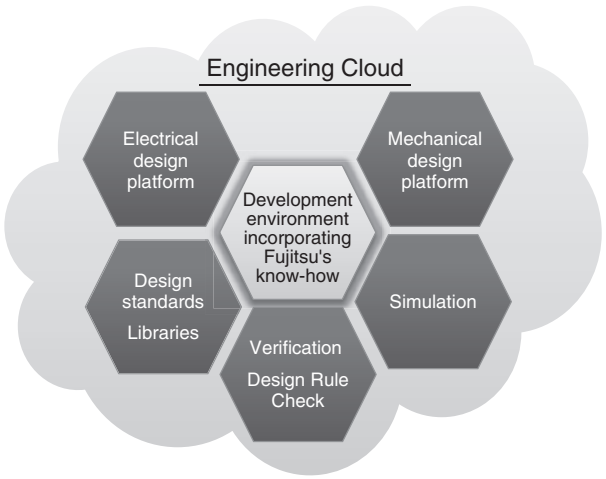

Figure 1
Development environment in Engineering Cloud.

3. Components of mechanical design platform

Figure 2 shows a structural concept of the mechanical design platform.

At the core is VPS technology, capable of accurately handling massive 3D data and providing high-speed 3D display. In addition to having the same functions as the conventional VPS (including digital mock-up, or DMU), it also has the so-called pre/post functions for analysis on the same VPS technology base. The same applies to various data conversion tools and shape correction tools. For example, they include conversion tools used on data of electrical

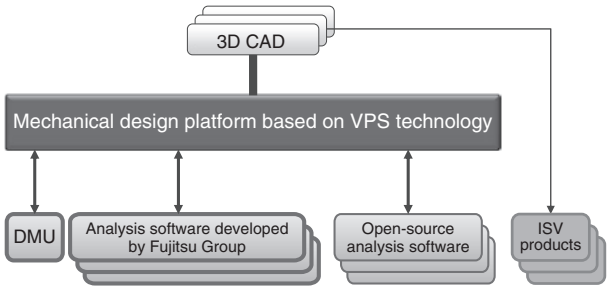

Figure 2
Structural concept of mechanical design platform.

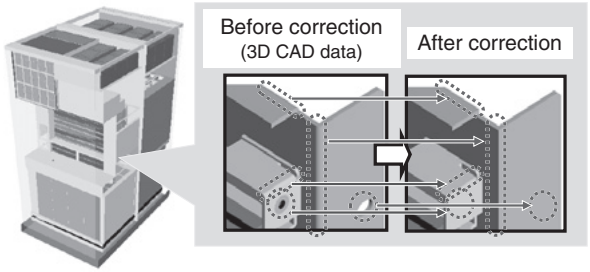

Figure 3
System to automatically correct shape.

design CAD for designing circuits of electronic components, wiring of printed circuit boards and layouts of electronic components on printed circuit boards. They also have mechanical design CAD for design of mechanical components and assembly into equipment so that they can be used easily for analysis. There are also tools for eliminating minute shapes (such as microscopic curved surfaces and screw holes) unnecessary to analysis for correction into the optimum shapes (**Figure 3**).

While the analysis solver itself operates as a different process, the analysis software developed by the Fujitsu Group and open-source analysis software are also being gradually migrated and linked to the mechanical design platform.

The approaches described above lead to the standardization of the basic operations of the pre/post functions and data types as well, which allows for easy management and improved distributability. For example, the verification function of VPS and preprocessing for thermal fluid or structural analysis can be realized with one data file. Accordingly, the analysis conditions in a certain design phase are associated, and this facilitates data management. The complex issue of the need for different tools and data types for different types of analysis is also eliminated.

Screenshots of a verification tool running on the mechanical design platform (examples of analysis condition setting and result verification) are shown in **Figure 4**.

4. Benefits in Engineering Cloud

Using the mechanical design platform means the user does not have to handle multiple tools and data files and makes it possible to produce drawings quickly and handle 3D shapes easily by using the VPS technology. However, it does not lead to the solution of three issues:

- Ensuring large computational resources required for analysis computation
- Handling files for massive computation results, etc.
- Ensuring resources required for visualization of massive computation results

The following describes the benefits of using Engineering Cloud to solve these issues.

1) Ensuring large computational resources required for analysis computation

Computational resources used by the mechanical design platform and analysis solvers have an efficient degree of parallelism according to the application or scale of computation. In addition, there is a question of whether to use CPUs or graphics processing units (GPUs) for general-purpose computing on graphics processing units (GPGPU) and the environment must ensure a good balance between CPUs and GPUs. With Engineering Cloud, we are working on enhancing hardware resources combining CPUs and GPUs in a well-balanced manner while comparing them with the advancement of analysis computation technology and state of its application.

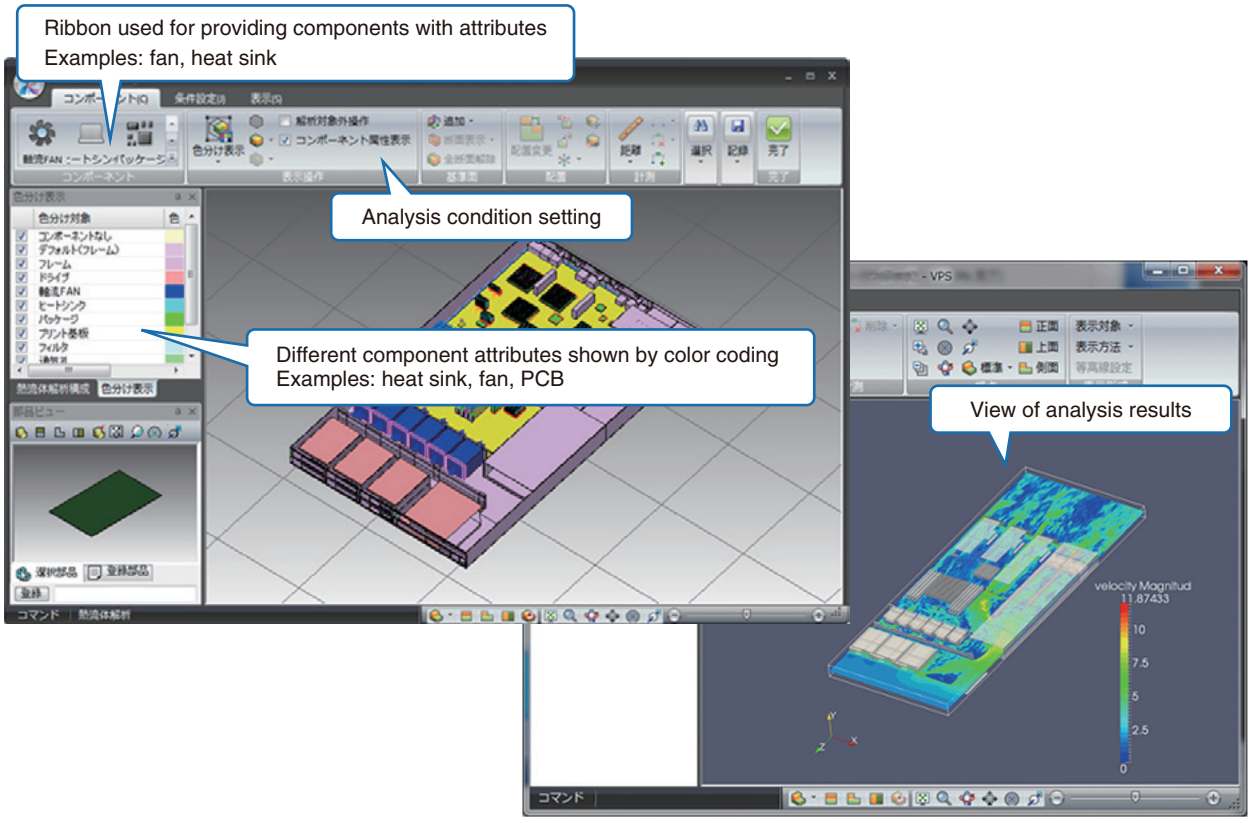

Figure 4
Screenshots of verification tool on mechanical design platform.

2) Handling files for massive computation results, etc.

Large-scale analysis has become possible as the availability of abundant computational resources is ensured, but this generates massive computation results. This means it is important to ensure a storage space for them and build an environment that does not require their transfer. The Engineering Cloud environment uses a technology that only exchanges screen information with users. In this way, the computation results remain in the cloud and network load caused by transfer can be reduced. Traditionally, the idea about the storage space for 3D CAD data used for analysis was to locate it near the user so as to reduce the load of data transfer and improve convenience. This space must be replaced with the Engineering Cloud environment. This is because locating 3D CAD data near the user does not reduce the distance in terms of network (**Figure 5**). For a similar reason, the operation of product data management (PDM) must be changed to a method suitable for the Engineering Cloud environment.

These approaches will allow the related data to remain in the cloud and facilitate efficient handling of 3D CAD design data, results of verification of VPS and analysis results.

3) Ensuring resources required for visualization of massive computation results

We see this as differentiation between the centralized and distributed processing of visualization computation. Specifically, it is an issue of how to use GPUs from the viewpoint of application software. For VPS, the real-time nature of image processing is the most important issue, and centralized processing is

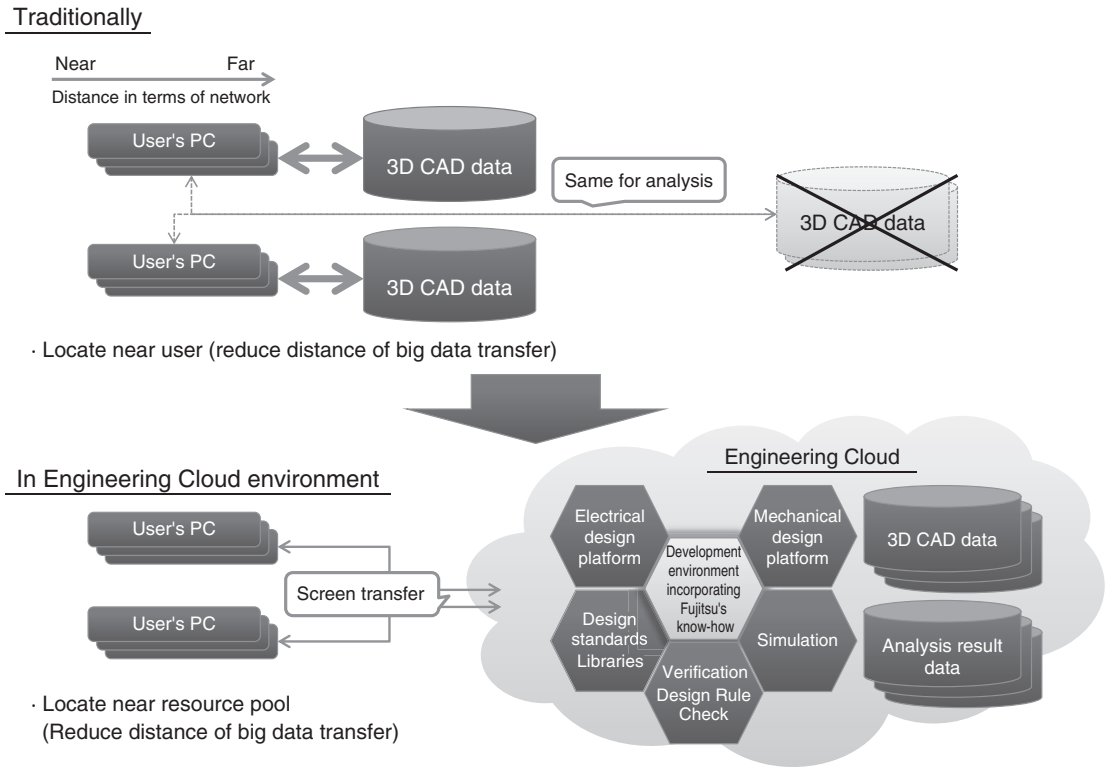

Figure 5
Example of concept of big data management.

preferable, although it depends on the scale. To verify the results of structural analysis, for example, data is often compared while calling multiple computation result files and distributed processing for each called file is usually efficient. For the results of thermal fluid analysis, the computation results for one case are massive and a process is generated in which the results are read at one time to identify the problems. Accordingly, measures must be taken for efficient distributed processing for one case.

The mechanical design platform allows such different ways of use. Basically, GPUs are used in a centralized manner as an extension of the high-speed visualization technology of VPS. Depending on the scale and purpose, they may be used for GPGPU.

Hardware resources of Engineering Cloud meet these requirements from the viewpoint of the mechanical design platform, which is software. In a cloud environment focused on high-performance computing (HPC) applications, GPUs are often used exclusively as computation resources for GPGPU. Engineering Cloud, meanwhile, has the benefit of providing an environment that allows use in the following three different ways.

1) Use of GPUs for image processing for the purpose of visualization
2) Use for GPGPU as preprocessing computation for the purpose of visualization
3) Use for GPGPU genuinely for the purpose of analysis computation

5. Future issues

One important future issue is linkage between clouds.

On the premise of an environment called inter-cloud[5] or hybrid cloud,[6] the mechanical design platform must be strengthened so that it can flexibly support even larger-scale analysis.

In addition to technological issues, there are

many points to consider in terms of operation. It is necessary to carefully work out the operational details. For example, developers must decide on the basic direction between closed use for Engineering Cloud, linked use with other internal cloud environments, linkage including external cloud services, and such like and on the relevant security policy and risk management. For the execution of individual tasks, they must judge the linkage with other clouds in a comprehensive manner based on the state of use of the Engineering Cloud environment and the costs for analysis data transfer, CPU utilization and analysis result transfer that will be required by the mechanical design platform.

6. Conclusion

This paper has presented the characteristics and benefits of the mechanical design platform in Engineering Cloud and its issues.

In addition to providing software tools as services in a cloud environment, identifying the troubles with them and eliminating them is important. To achieve their aims, engineering service users often utilize multiple tools for different purposes, which is a process with a lot of underlying problems. We have introduced an example of how to use a mechanical design platform that improves the situation by standardizing operations from the perspective of users and hiding data types.

For even more efficient use of this mechanical design platform, we need to provide an environment that allows flexible use of computational resources required for analysis, resources for storing and transferring massive analysis result data and resources required for virtualization according to the purpose. From that perspective, we have shown the benefits of and future issues with use of Engineering Cloud.

References

1) K. Miyazawa: Fujitsu's Approach to Cloud Computing. *Fujitsu Sci. Tech. J.*, Vol. 47, No. 4, pp. 371–377 (2011).
2) T. Tenma et al.: VPS Plays Central Role in Cooperative Development of Products. (in Japanese), *FUJITSU*, Vol. 55, No. 3, pp. 227–231 (2004).
3) T. Yamaguchi et al.: Integrated Design Environment to Support Innovative Manufacturing, *Fujitsu Sci. Tech. J.*, Vol. 43, No. 1, pp. 87–96 (2007).
4) S. Saito et al.: Engineering Cloud: Flexible and Integrated Development Environment. *Fujitsu Sci. Tech. J.*, Vol. 47, No. 4, pp. 408–417 (2011).
5) Global Inter-Cloud Technology Forum (GICTF): Use Cases and Functional Requirements for Inter-Cloud Computing. (in Japanese). *http://www.gictf.jp/doc/GICTF_Whitepaper_20100809.pdf*
6) M. Funabashi et al.: Fujitsu's Approach to Hybrid Cloud Systems. *Fujitsu Sci. Tech. J.*, Vol. 47, No. 3, pp. 285–292 (2011).

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