Construction of Integrated Design Development Environment and Its Deployment on Cloud

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It is crucial for manufacturers in fierce competition with global vendors to continue providing products incorporating the functions, performance, quality and environmental resistance desired by customers faster and at lower costs while meeting the diversifying market needs. Accordingly, there is an urgent need to construct a global design and development environment that accelerates development while utilizing more than ever the "knowledge" existing in the fields of development and manufacturing. Fujitsu has launched and utilized a design and development environment for wide-ranging products including supercomputers, servers, network devices and mobile phones as an in-house private cloud for integrated design. We also offer this environment to external customers through forms of clouds in line with the respective customer needs as a next-generation manufacturing infrastructure service. This paper presents the integrated development environment that Fujitsu established by developing and introducing advanced cloud technology to a design and development environment that contains Fujitsu's many years of manufacturing know-how. The overall picture, characteristics and future direction of this integrated development environment are described.

1. Introduction

It is crucial for manufacturers in fierce competition with global vendors to continue providing products incorporating the functions, performance, quality and environmental resistance desired by customers faster and at lower costs while meeting the diversifying market needs. Accordingly, there is an urgent need to construct a global design development environment that accelerates development while utilizing more than ever the large amount of "knowledge" existing in the fields of development and manufacturing.

As the leading information and communications technology (ICT) company, Fujitsu is proposing virtual products and virtual factories in various processes from the upstream to the downstream of manufacturing and promoting efficiency improvement and optimization in the actual fields of manufacturing as well as design and production.

We have established a design development environment for all products ranging from supercomputers, servers and network devices to personal computers (PCs) and mobile phone handsets as in-house private cloud for integrated design. We also offer these structures of an in-house reference system to external customers through forms of clouds in line with their respective needs as a next-generation manufacturing infrastructure service.

This paper presents the integrated design development environment that Fujitsu established by developing and introducing advanced cloud technology to a design and development environment incorporating Fujitsu's many years of manufacturing know-how. The overall picture, characteristics and

future direction of this integrated development environment are described.[1)–4)]

2. Fujitsu's integrated design development environment (Flexible Technical Computing Platform: FTCP)

In the fields of product development, important issues are reducing costs, accelerating development and accumulating and sharing the knowledge existing in many fields. Traditionally, an unsophisticated trial-and-error process of repeated prototyping and testing was unavoidable in product development. Recently, innovation of the development process has been under way by utilizing simulations for design verification so as to incorporate and use various types of knowledge in ICT systems. Undoubtedly, the level of excellence of the ICT usage environment in the fields of development is directly linked to the competitiveness in product development.

Fujitsu has built many years of development and manufacturing know-how into an ICT system as a technical computing platform to establish a structure for making use of ICT in various processes including planning, development, manufacturing, maintenance and service. We take thoroughly scientific approaches to manufacturing and, by making use of a closer linkage between science and engineering, we are aiming to strengthen our competitiveness and improve our development speed through accumulating and utilizing technological know-how. **Figure 1** shows a map associating the development technologies mentioned in this paper with stages of manufacturing.

Fujitsu's integrated design development environment (Flexible Technical Computing Platform: FTCP) (**Figure 2**) integrates and interlinks various development technologies (tools) required in the development process of a product on a common platform and supports the entire lifecycle of a product (product lifecycle management: PLM) encompassing device design, component selection, circuit design, component placement/wiring design, mechanical design and manufacturing line design. It makes use

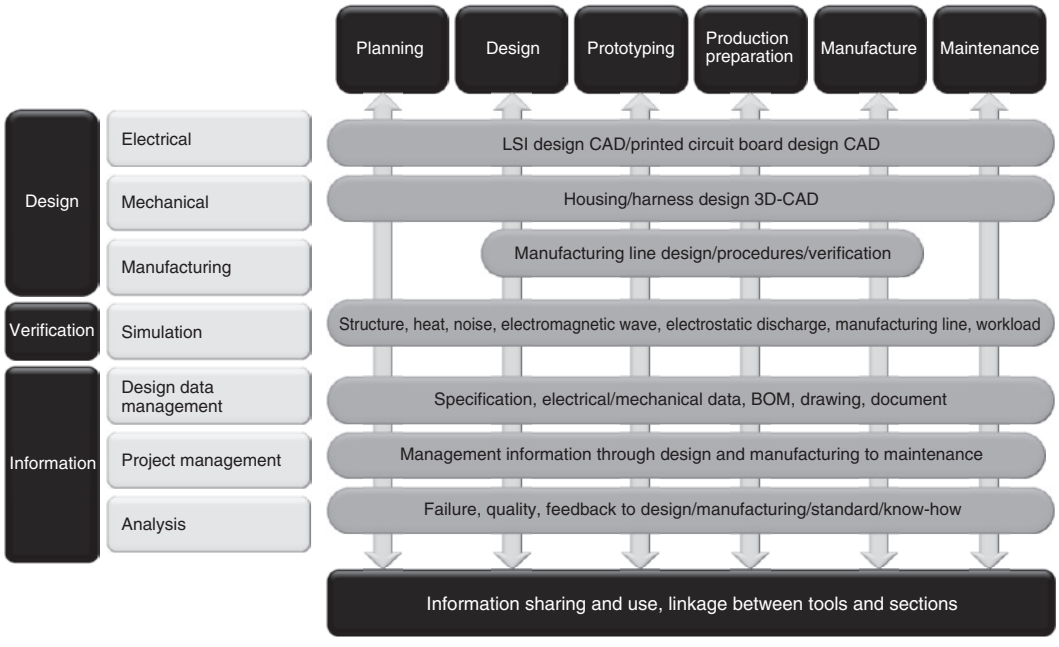


Figure 1
Map associating stages of manufacturing with development technologies.

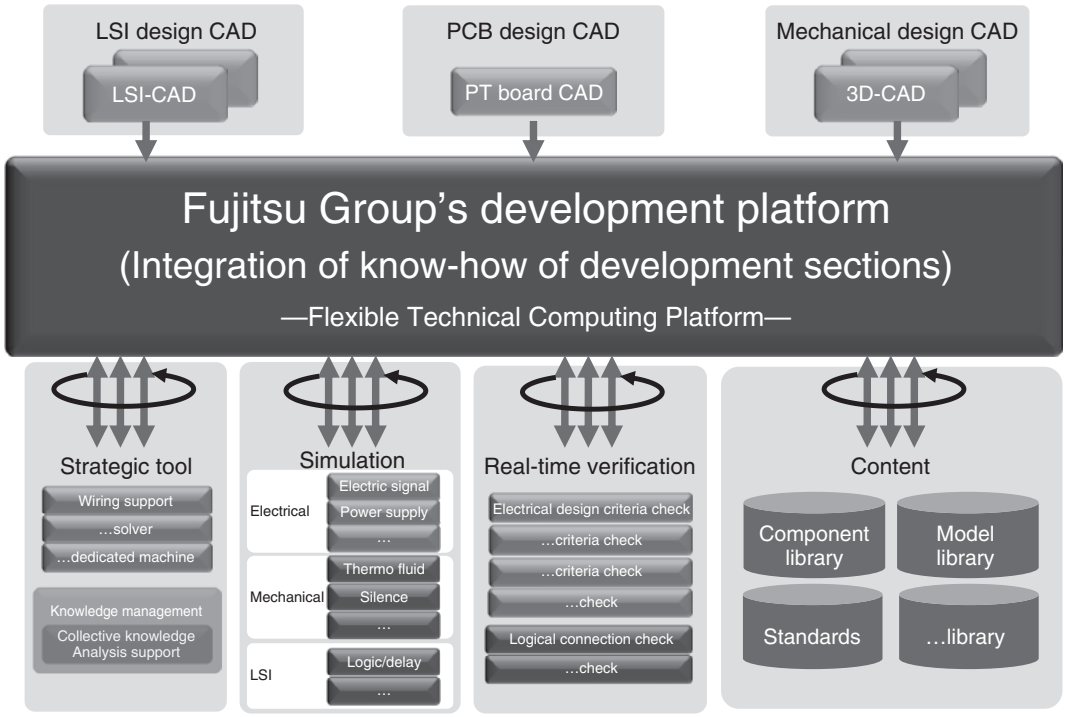


Figure 2
Fujitsu's integrated design development environment (FTCP).

of the 3D design technology to realistically and virtually represent PCB unit mounting and component structures to allow efficient advance verification of ease of assembly, maintainability and environmental performance.

This process includes conducting a simulation on electric current and field distributions on PCBs so as to study the state of noise emission and predict antenna characteristics of notebook PCs and mobile phones. It is used for diverse types of verification including predicting the dynamic behavior of a product resulting from an impact when it is dropped and points of stress concentration of the main unit of a computer caused by seismic waves, and analyzing heat in housing and the air conditioning flow in a data center.

In addition, we are applying our design and manufacturing know-how built up over many years to CAD tools as real-time verification (Design Rule Check: DRC) for practical use. We are also incorporating models, physical properties and component libraries so as to achieve more accurate simulation results, which are interlinked and integrated.

In the future, we intend to pursue development and manufacturing styles that are befitting of Fujitsu. These include reproduction of design data in a virtual line of a virtual factory capable of efficient process design in a factory and diverse evaluation and verification to allow simultaneous verification of the degree of completion of product design and mass productivity.

3. Construction of in-house private cloud for integrated design

In 2000, Fujitsu built a large-scale application service provider (ASP) environment by consolidating software licenses and servers for simulation computation leading the industry, and this has been made use of by several thousand designers in charge of product development.

However, with product development becoming increasingly sophisticated and complicated, innovative simulation technology that allows highly accurate analysis of multi-scale, multi-physics phenomena, in which multiple phenomena influence each other, is required and computational complexity has dramatically increased along with support for larger-scale simulation.

In addition, distribution of development bases, utilization of digital data in the fields of manufacturing and maintenance and acceleration in development cooperation at a global level are in progress, and this has made support from ICT indispensable in the respective fields.

With these situations in the background, it has become essential to construct a safe and secure design development environment that is more sophisticated and homogeneous and can be used globally.

We are working to address these challenges and also systematize and share the know-how of sections in the enterprise, which is still scattered in various fields, as company-wide know-how so that it can also be used to create new values. To this end, we have developed and introduced advanced cloud technology to construct an in-house integrated private cloud and offered it to the development section as a desktop as a service (DaaS) environment (**Figure 3**).

Compared with the general enterprise operations such as personnel and administration activities, accounting and purchasing, for example, the engineering field of product development is facing the following challenges in particular and migrating the existing system as it is to a cloud seems difficult.

- Demand for interactive use of massive amounts of data
- Need for high-performance PCs with a

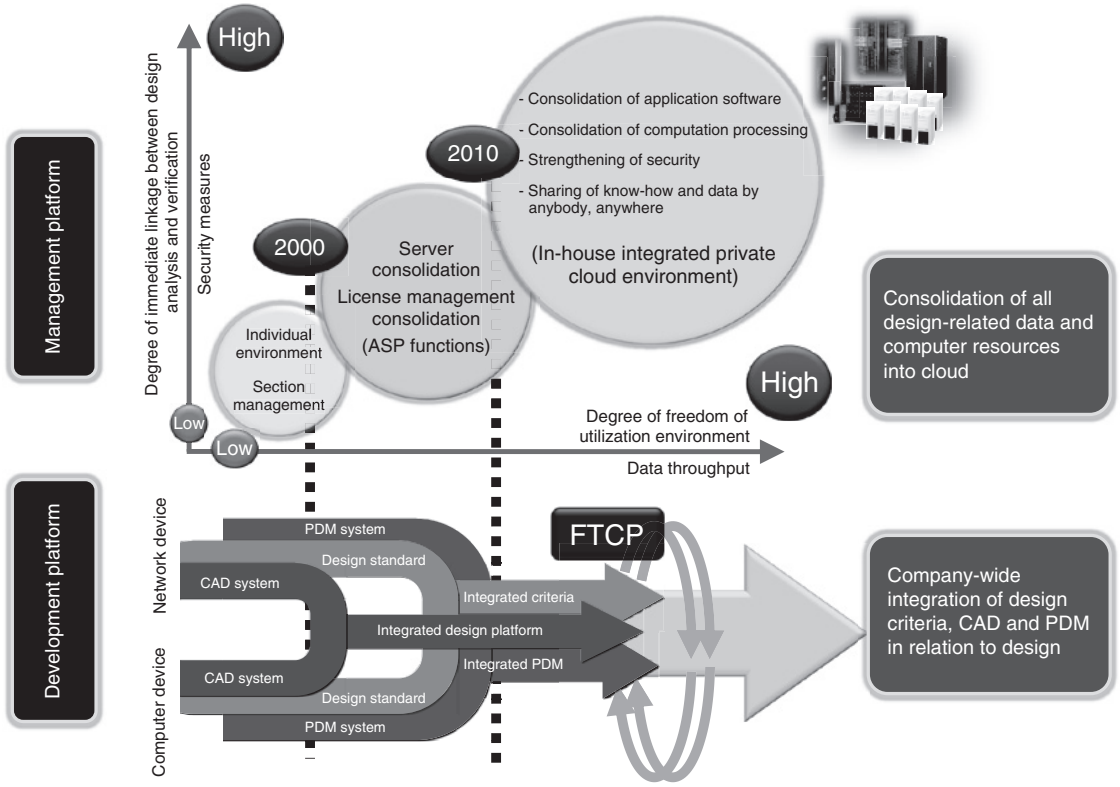


Figure 3
Migration of integrated design development environment to private cloud.

graphic board
- Demand for use of more ICT resources than the computer resources allocated to individual designers
- Demand for more licenses for development, which is expensive
- Demand for use of a similar environment in factories and business trip locations
- Demand for security in handling the enormous amount of confidential information

4. Features

To construct a private cloud as an integrated design environment, we have developed and enhanced various elemental technologies and applications.

4.1 High-speed display technology: Remote Virtual Environment Computing (RVEC)

If the present cloud technology is used as it is, applications for CAD and simulation are installed in a cloud environment and it is accessed from a distant client terminal. Therefore, the image display speed on the client terminal may be significantly slowed to an unpractical degree because of the transfer of a massive amount of data and physical network delay.

To deal with this problem, Fujitsu has developed industry-leading, high-speed image display technology, reducing transfer time by reducing amount of compressed data comparing to well-known method, so as to realize a cloud in the field of engineering. This has allowed design data and application software to be used as a DaaS environment offering a similar feel of operation to that of the existing desktop environment without requiring them to be loaded onto a client terminal.

4.2 Portal technology

We have provided an integrated design portal used by several thousand people from various Fujitsu Group companies. We have developed functions for reconstructing the PaaS (platform as a service) that are offered in the conventional ASP environment (including authentication, license management, hardware monitoring, results aggregation, billing calculation and accounting system linkage). But also, we have developed additional functions as shown below as new cloud services.

1) Functions in relation to services provided in virtual environment
- VM use application management, results aggregation, billing
- VM template management, VM allocation management

2) Service provided in DaaS environment
- Provision of high-speed image display function (for different OSes)

4.3 Highly accurate simulation technology

We believe that making full use of advanced simulation technology and large-scale computer resources will lead to considerable innovation in future ways of development and the roles of engineers. There will be a transition from an age of design verification by using computers to an age of manufacturing by computers, in which design proposals, optimized by means of a simulator in view of various design factors, are confirmed by designers as the end stage.

Figure 4 shows the relationship between computing power and analysis accuracy, or so-called error. When the granularity of an analysis model, or so-called the degree of meshing, is decupled, the analysis errors are reduced by half. Accordingly, if ICT resources are enhanced and utilized, simulations that are more accurate than experiments will no longer be unrealistic and may contribute to dramatic efficiency improvement and early application of new materials and construction methods in the fields of manufacturing.

For unlimited pursuit of "consistency with things," in addition to the utilization of large-scale ICT resources, solver performance capable

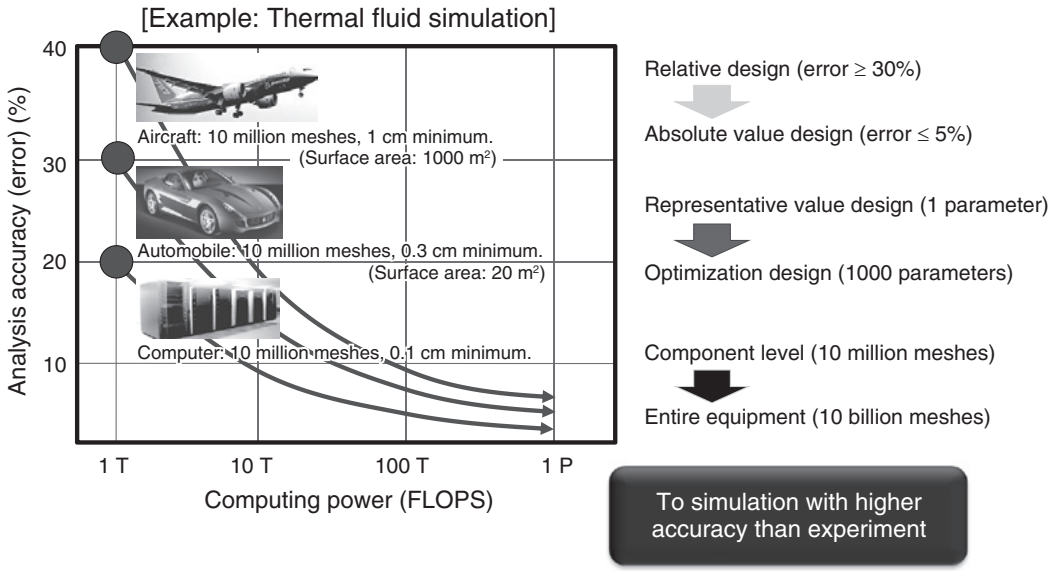


Figure 4
Relationship between ICT resources and analysis accuracy.

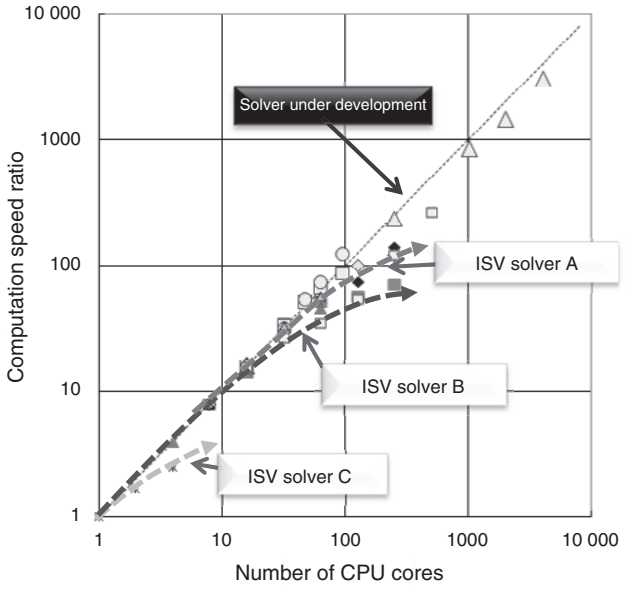


Figure 5
Development of large-scale, massively parallel solver technology.

of maximizing the performance of those ICT resources is important.

Figure 5 shows an evaluation of the number of CPUs and performance of representative general-purpose solvers. Many tools start to loose scalability of computational performance with a few to a 100 CPUs, although it depends on the type of solver, and the acquisition of large-scale, massively parallel solver technology is essential.

Fujitsu is working on the development of massively parallel solvers incorporating proprietary know-how for ICT devices while making use of open-source software (OSS), which is currently in the phase of final verification through actual operation in the development site.

5. Expansion of fields of application

The present in-house private cloud for integrated design has made it possible to share various types of design data among more fields. In addition to the existing use in the design section, the manufacturing engineering, manufacturing and maintenance sections can now use the same data as the design section when required in the form required. This is contributing to greater operational efficiency, ingenuity and co-creation in various fields.

In the manufacturing engineering section, for example, making use of 3D CAD data designed and verified in the integrated design environment can be developed into a production

preparation assistance tool (GP4). This will allow a virtual production line to be reproduced in a virtual factory for verification of production preparation operations including the verification of productivity, operability and layout efficiently in a short time (**Figure 6**).

Furthermore, in the manufacturing section, the conventional work procedures and assembly instructions on paper are being replaced by digital procedures displayed in real time on the operation ICT terminal for checking the details of operations. Also, CAD data shown on a thin client PC can now be viewed to analyze points of failure for efficient investigation. In this way, advanced cloud technology can make design data be used more and more in the fields of manufacturing (**Figure 7**).

In the maintenance and repair bases nationwide, the necessary maintenance data and design information can now be obtained in a timely manner through this cloud environment without having to put a special machine environment in place. It may be a matter of time before repair points can be promptly detected and handled, and paper manuals, which have existed in enormous numbers, disappear from fields (**Figure 8**).

6. Development into external business

Fujitsu is developing business by offering as a reference model the various types of in-house manufacturing know-how and tools it has built up in the field of digital engineering in the group. These mainly include the development environment and technology described in this paper, which is a next-generation manufacturing environment to support manufacturing of a new age.

We intend to offer them in various forms of service including private cloud, SaaS and PaaS according to the environment and characteristics of the individual customers (**Figure 9**).

As the SaaS model, applications for CAD, simulation, product data management (PDM), and such like offered by Fujitsu so far will be

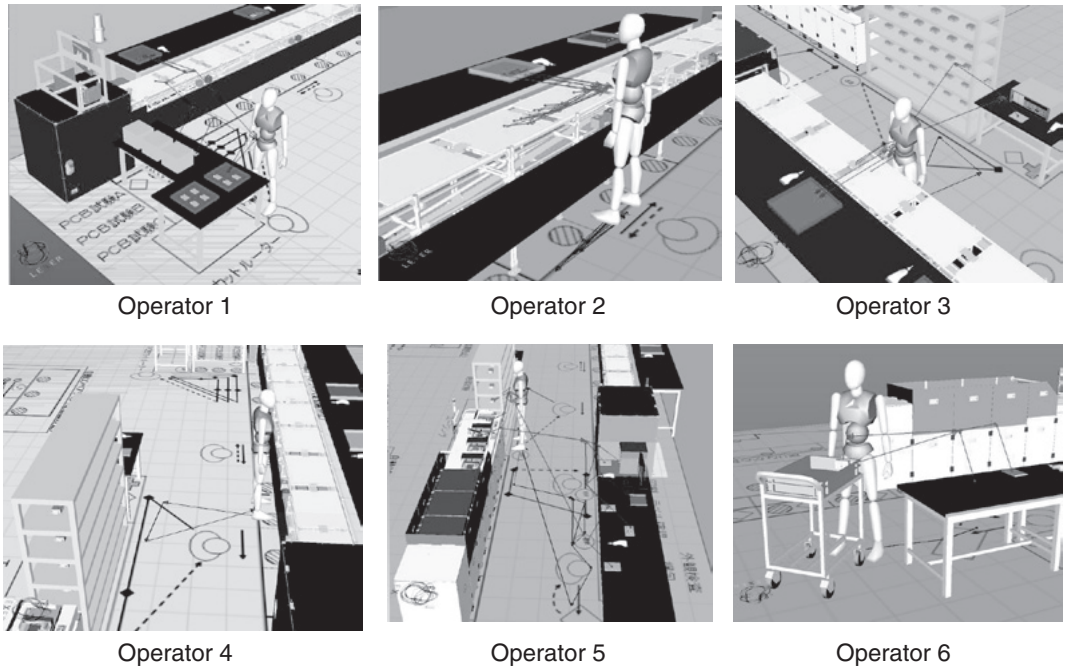


Figure 6
Production line verification by making use of GP4.

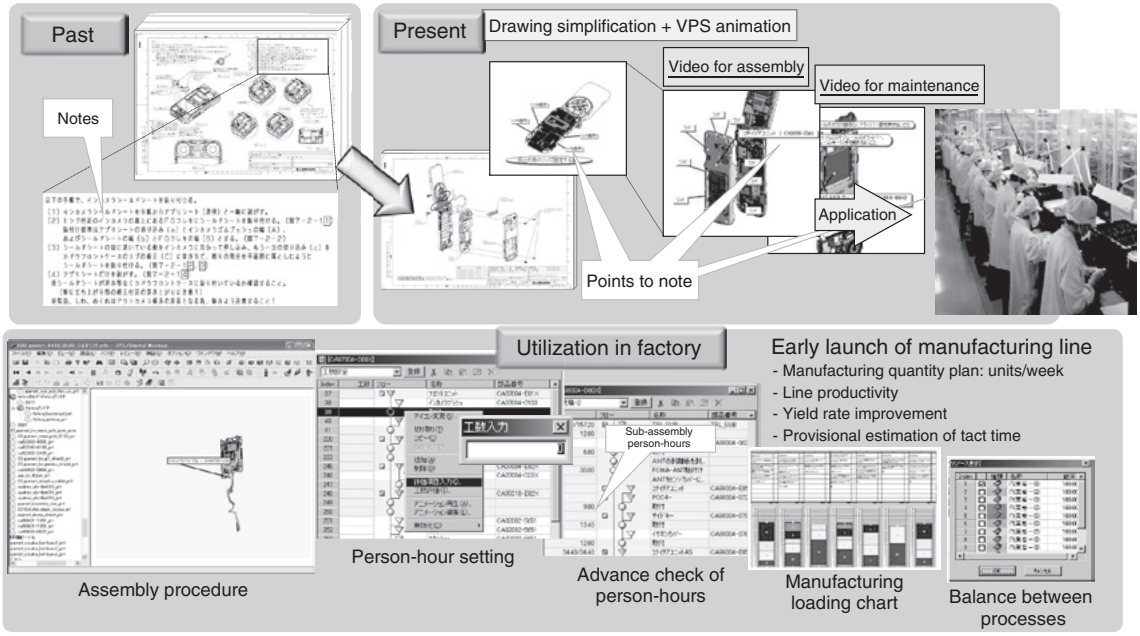
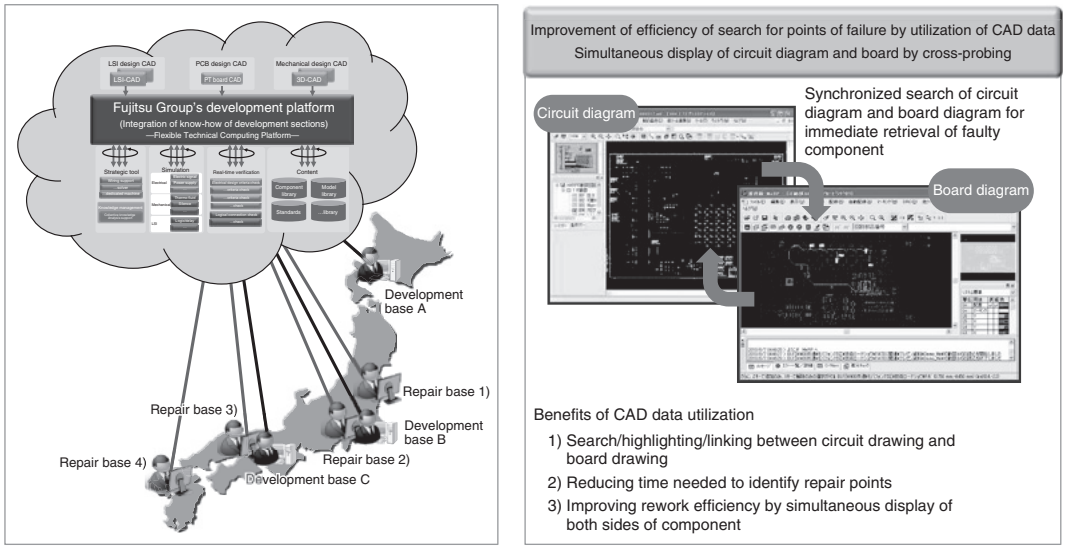


Figure 7
Utilization of design data in manufacturing section.



(a) Utilization of CAD data at development/repair bases (b) Search by referencing CAD data at repair bases

Figure 8
Utilization of design data in repair and maintenance section.

provided as SaaS. In addition to these, the product development know-how and methodology used in the fields of manufacturing of the Fujitsu Group will be incorporated into a cloud platform, which will also be offered as the "manufacturing know-how service."

The PaaS model includes the provision of a high-speed, thin client environment that supports next-generation manufacturing. This will allow customers to run original applications optimized for their own operations on the Fujitsu cloud platform or on the premises. This is

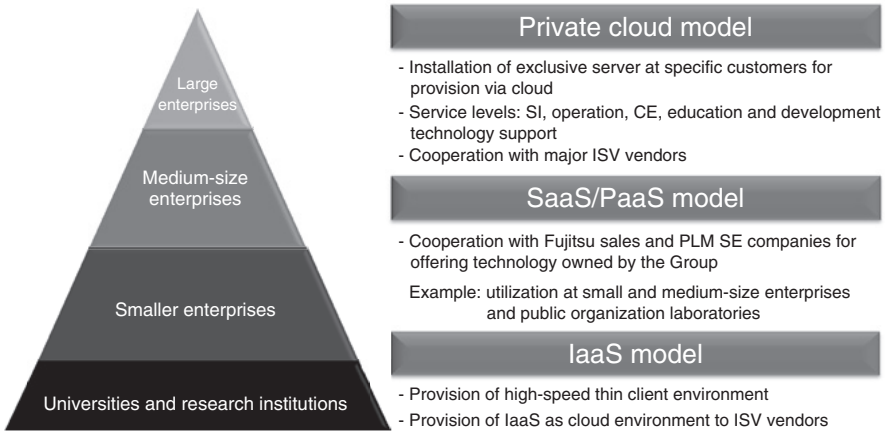


Figure 9
Forms of service meeting customer needs.

expected to help create new values such as data analysis.

At present, Fujitsu is incorporating its ICT into customers' products and services to offer solutions capable of directly providing value to customers' businesses, which is called the "NextValue" activity. In addition, Fujitsu is promoting "manufacturing innovation" as an approach to giving direct support to customers' businesses and intends to incorporate the reference system mentioned in this paper as a service menu.

7. Conclusion

Under the vision of Human Centric Intelligent Society, Fujitsu aims to become a technology-based global service enterprise.

The migration of development environments to the cloud is expected to increasingly accelerate along with the advancement of ICT and we intend to continue to refine these technologies, thereby creating new added values and further strengthening the development environment and technologies.

In addition to the knowledge and information obtained from the fields of development and manufacturing, various types of data from maintenance, customer usage and logs can be taken into the integrated design development environment for accumulation and analysis. This we believe will allow new ideas to be incorporated into the design specification and development methodology in the fields of development.

We will make use of in-house practical know-how obtained through these activities so that we can provide customers with a development environment and technology that take advantage of ICT in the fields of manufacturing, where functional enhancement and sophistication will more rapidly progress in the future. In this way, we intend to make contributions to improving the product competitiveness of customers and help them overcome manufacturing challenges.

We are committed to taking thoroughly scientific approaches to technology and manufacturing and pursuing a style of manufacturing that befits Fujitsu.

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