Electrical Design Platform on Engineering Cloud

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The conventional requirements of *monozukuri* (manufacturing) included needs for high performance, miniaturization, low costs and fast development. In addition to these, product development has come to require businesses to fulfill their social responsibilities in areas such as business continuity and consideration for the environment and safety. In order to respond to these changes in technologies and the business environment, it is essential to introduce development processes and a development environment that allow for effective governance of development overall. Fujitsu has integrated the know-how of *monozukuri* cultivated over many years, and built Flexible Technical Computing Platform (FTCP) as the integrated design development environment. It has provided it to customers in development sections, manufacturing sections and repair sections as "Engineering Cloud." This paper describes an overview of FTCP. It also covers the features of and linkage between CAD for designing printed circuit boards, a key component of the electrical design platform; a simulation environment for analyzing noise and such like; and a standard component database which supports them. Moreover, it also describes the merits of providing FTCP in a cloud environment by using Engineering Cloud, and the shift of customers' existing development environments to the cloud.

1. Introduction

Monozukuri (manufacturing) is becoming more and more difficult every year with the increasing number of factors to take into account in product development due to the evolution of technology and changes in the business environment. These factors include analog behavior of digital signals resulting from higher-speed semiconductor devices, noise margin decrease due to reduced voltage, and miniaturization and density increase as is seen in smartphones. Meanwhile, there are urgent demands for a shorter time-to-market and lower costs because of global competition, and a shorter development lead time and low-cost development are now essential. In addition, business requirements such as business continuity, consideration for the environment and safety are increasingly demanding as part of corporate social responsibilities. In these technology and market environments, standardized and governed product development process and innovation of the development environment that supports the process are becoming indispensable.

This paper describes a development environment that allows product development lead time to be reduced and quality and performance to be improved, and is speeding up the Fujitsu Group's *monozukuri*. This paper presents a design and verification environment, standardized standard component database and approach to operation in a cloud environment with the focus on the electrical design platform.

2. Integrated design development environment: FTCP

As an environment assisting manufacturing innovation, Fujitsu has worked on constructing

EMAGINE, a design environment that supports development with no rework required from design to manufacturing.[1)]

To further evolve and integrate this environment into a development platform, we are now building Flexible Technical Computing Platform (FTCP), an integrated design development environment that consolidates development know-how in manufacturing and makes use of technical computing (**Figure 1**).

FTCP provides on the platform a GUI-based CAD environment, real-time verification (Design Rule Check [DRC]) environment for signals, power, heat and mechanisms and a design standard and standard component database (library) that supports them. In this way, it assists in the development process from the upstream of the design process to manufacturing.

Furthermore, to perform enormous amounts of computation for purposes including high-accuracy analysis and simulation in short periods of time, it offers technical computing resources consisting of PC clusters and grid computing.

There are three major points in the electrical design environment in FTCP, and they are described in the following sections:

1) Electrical CAD tools and DRCs integrating design know-how and technology
2) Complete electrical simulation by making use of technical computing
3) Standard component database that supports the standardization of components and design verification

3. Electrical design CAD

Electrical design CAD consists of tools that support an entire range of processes from concept design, which is the upstream area of the design process, to detail design and manufacturing (**Figure 2**).

These tools incorporate design and verification know-how built up over many years by Fujitsu so as to support the design of large boards for supercomputers, servers and network

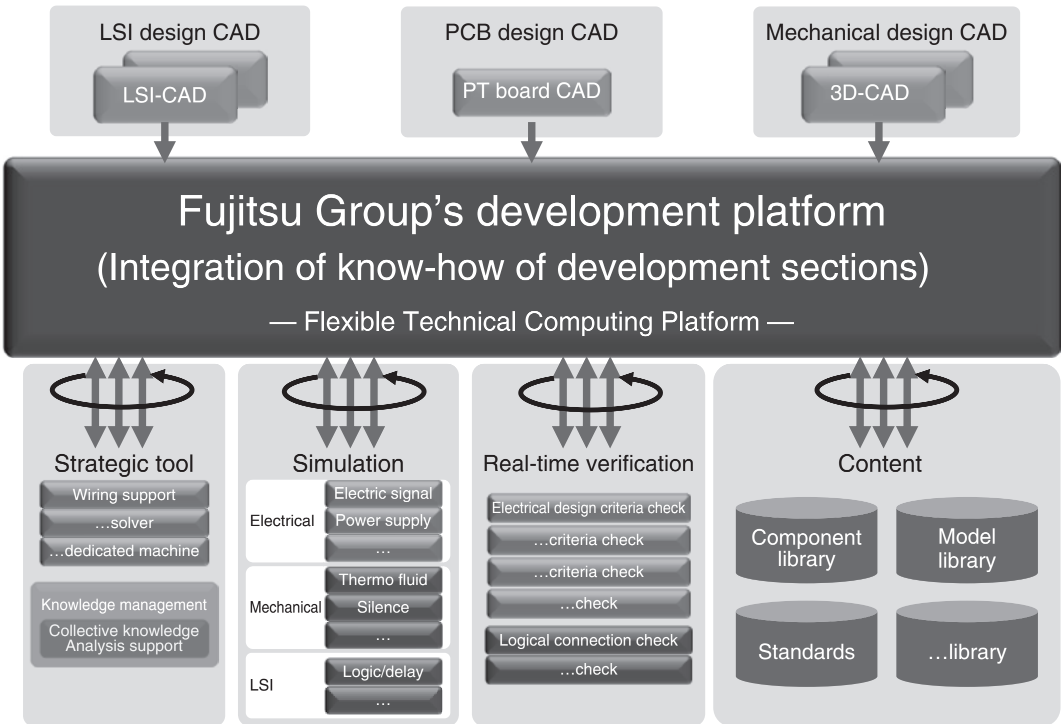

Figure 1
Fujitsu’s integrated design development environment (FTCP).

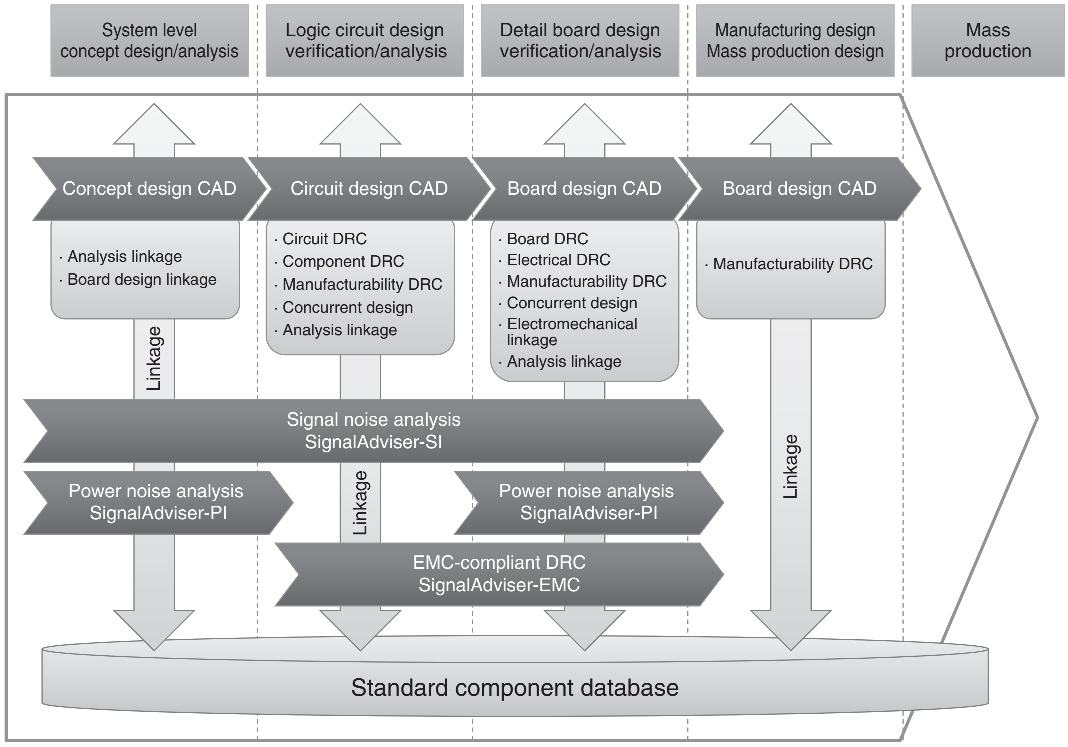

Figure 2
Design/verification tools and standard component database supporting development process.

devices and small high-density boards for mobile phones and notebook PCs.

3.1 Concept design

In the concept design process, multiple cases are compared to study the size, layer configuration, rough layout of key components and wiring routes of a printed circuit board (PCB) so as to select the optimum solution among them. This is then handed to the following detail design process as the board design specifications. To prevent major rework in the subsequent processes, concept design CAD tools for printed board design and different analysis tools are used for various types of verification and evaluation including component layout/wirability, signal integrity, power integrity, heat generation characteristics and manufacturability.

To make it easier to use CAD in the concept design process, which is the uppermost stream of design, the concept design CAD allows a design to be started simply by creating the PCB and component shapes using a wizard. In addition, the PCB shape, layer configuration and component shapes can be freely changed in the process of component layout/wiring editing, thus allowing designers to easily study board designs of various cases.

The results of design undergo an evaluation in terms of the component layout location, wiring route information, wiring length, power pattern, and such like. This is done by making use of the linkage with the signal integrity and power integrity analysis tools, which provides design conditions that are used in detail design as design constraint conditions.

3.2 Detail design

The detail design process includes component selection, circuit design, wiring constraint design and board design.

1) Component selection

Component selection is an important process that has an impact on the performance, reliability and cost of a product and the choice of components is refined in a real-time search of the component database described later from the circuit design CAD. An automatic collective replacement function to replace end-of-life components with alternatives and environmental regulation-ready components is provided and a system to promptly use standard components is realized.

2) Constraint-driven design and wiring support

In designing a board that is to handle high-speed signals, wiring in compliance with rules such as pattern wiring length and wiring topology is essential. For this reason, those wiring constraints must be applied to signal lines on the circuit diagram in the circuit design phase. Large circuits may have thousands of wiring constraints and, as an efficient means of making settings and verifying them, a function of editing in a circuit topology between drivers and receivers for signal transmission is provided.

As wiring support functions to help in wiring a board based on the constraints, a board design is equipped with functions for ensuring spacing and shielded wiring for preventing crosstalk noise, equal-length wiring for differential pair signals and equal-length bus wiring to reduce wiring work and wiring constraint errors. In addition, a system is provided in which a real-time DRC constantly checks the wiring pattern during editing to ensure the wiring is in keeping with the design criteria and wiring constraints.

3) Reduction of rework by DRC

DRC to ensure adherence to Fujitsu's design criteria and verify the soundness of design includes about 100 items in circuit design and about 200 items in board design and manufacturing design, which is shown in **Figure 3**. Many of these are applied in real time simultaneously with design editing so as to offer functions to ensure error-free design. High-response performance is also achieved for collective DRC, which is conducted at breaks in the design process, to provide an environment that allows design and verification to be conducted at the same time. The DRC environment incorporates Fujitsu's product development know-how and is reviewed and

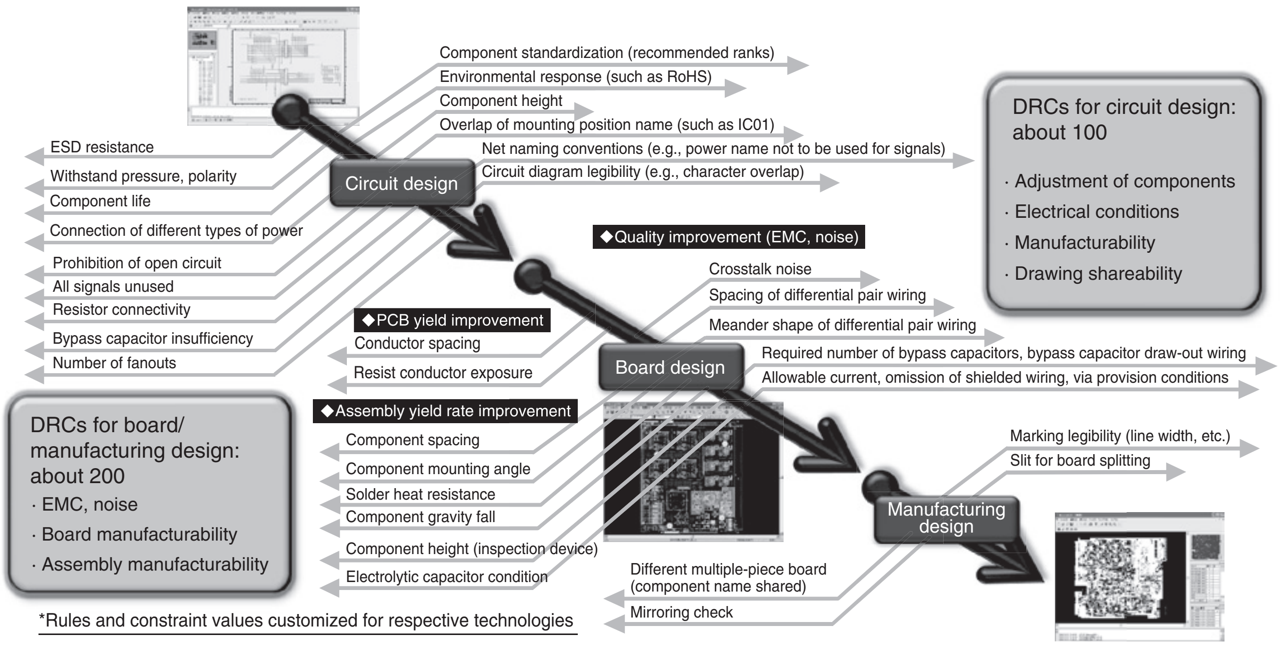

Figure 3
DRC realizing design/manufacturing know-how.

enhanced on a daily basis in order to keep up with the latest technologies and in response to feedback on failure case examples.

3.3 Manufacturing design/mass production design

To reduce the number of prototyping times and manufacturing lead time, Design For Manufacturing/Design For Test (DFM/DFT) in view of ease of manufacturing and testing processes is meticulously implemented in the design phase.

This includes the unification of the component mounting orientation to reduce the mounting time by mounter and checks on distances between components, component height conditions and allowable temperature limit to improve the solder reflow yield. In addition, verification of temperature distribution in reflow by a thermal analysis simulation is also conducted to ensure manufacturing quality and improve efficiency.

For testing after manufacturing, boundary-scan circuitry in accordance with Joint Test Action Group (JTAG) is integrated and the function for automatic test pattern generation and test pad arrangement for automatic test equipment are provided in the design phase, thereby improving the testing process efficiency and diagnosis rate.

4. Electrical simulation

As the signal transmission speeds on mount boards increase along with the enhancement of digital device performance, voltage decrease and mounting density increase of LSIs are in progress. This has revealed noise problems in signal transmission and power supply systems. In addition, the increase of the electromagnetic interference (EMI) emission level has made it difficult to clear the EMI regulation tests and ensure electrostatic discharge (ESD) resistance. In making designs to address these noise problems, various noise analysis systems and the Electrical Design Rule Check (EDRC) system are optimally combined in the respective situations to be utilized. These systems are incorporated into the design processes of Fujitsu's wide-ranging devices including mobile phones and the K computer,[note)] which has allowed various noise measures to be built in the upperstream phase of design and made significant contributions to the elimination of design rework and cost reduction.[2)]

The following describes electrical simulation systems.

4.1 Transmission waveform analysis system: SignalAdviser-SI

Of signal transmission, over-Gb/s differential transmission, in particular, can have transmission waveforms significantly affected by skin effect, dielectric loss and intersymbol interference (ISI), which necessitates high-accuracy analysis of these phenomena. Fujitsu's transmission waveform analysis system has an originally developed circuit simulator engine integrating a highly accurate analysis function for frequency-dependent parameters to allow highly accurate analysis of these phenomena.

4.2 Power noise analysis system: SignalAdviser-PI

The existing design method of addressing power noise with desk calculations has low accuracy, and this has made it very difficult to come up with a design that addresses power/ground bounce noise. For this reason, higher noise countermeasure design costs due to excessive design and, conversely, power noise problems because of insufficient noise countermeasure design have often been revealed.

Fujitsu's power noise analysis system integrates functions essential to power noise countermeasure design in addition to power impedance analysis and direct current drop

note) The English name that RIKEN has been using for the supercomputer since July 2010.

analysis, and they have been applied to device design to eliminate the generation of power noise problems.

4.3 EMC-compliant DRC system: SignalAdviser-EMC

There is a need to allow EMI/ESD measures to be easily built, something that has been becoming increasingly difficult, in the design phase. To this end, a DRC system incorporating the electromagnetic compatibility (EMC) know-how cultivated by Fujitsu through design of various devices ranging from mobile phones to supercomputers has been constructed and utilized. In many cases of device development, it has successfully eliminated design rework resulting from defects found in EMC standard tests with actual devices, which occurred in the past. This system features:

1) Wide application to devices ranging from mobile phones to high-end servers
2) Capability of checking on ESD resistance as well as EMI
3) Function of weighted display/report output of check results
  - Priorities of measures weighted and important items extracted.
  - Detail and summary reports output for easy instructions on measures.
4) EMI field intensity spectrum analysis of wiring patterns
  - Field intensity spectrum automatically analyzed based on PCB layout data (**Figure 4**).
  - Appropriate EMI countermeasure design realized by integrating a highly accurate electromagnetic field solver originally developed.

As shown in Figure 4, use of an EMI-compliant component based on the results of analysis has successfully reduced the field intensity by 10 dB.

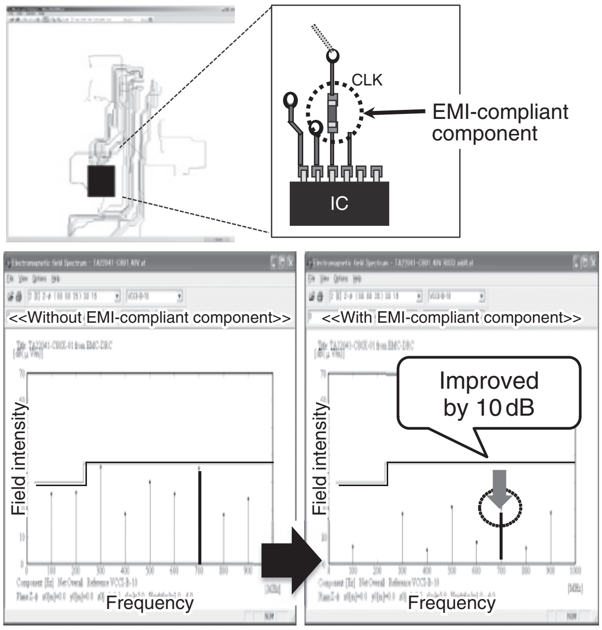

Figure 4
Example of application of function to analyze field intensity spectrum.

5. Standard component database

A standard component database is what provides component information essential to highly accurate and efficient operation of the electrical CAD/DRC and electrical simulation described up to now. The Fujitsu Group has standardized components in the Group. This has led not only to the reduction of redundant work involved in component selection and evaluation but also to various benefits including cost reduction by centralized purchasing, reduction of acceptance inspection work at plants and reduction of component inventory.

In addition, close linkage between the standard component database and CAD has allowed more efficient design using CAD and highly accurate DRC and simulation at an early stage of design, thereby improving the efficiency of design, ensuring design quality and reducing rework from downstream processes.

As of 2011, general-purpose electronic components registered in the standard component database include about 50 types and 240 000 items of ICs, LSIs and electromechanical components. Of these, components recommended for use are being standardized by narrowing down to 17 000 drawing numbers. For each component, about 380 to 430 types of attribute information are registered as component management information, function/characteristic information, quality information, manufacturing information, procurement information, environmental response information and design information. The following outlines the respective types.

1) Component management information

Drawing numbers, manufacture/model information and standardization information (recommended ranks) used for purchasing components

2) Function/characteristic information

Component-specific function information and characteristic information including rated voltages, temperature characteristics and frequency characteristics

3) Quality information

Component-specific failure rates reflecting the operational status of the actual products

4) Manufacturing information

Information including reflow heat resistance information, moisture absorption control information, storage management conditions and forms of packaging

5) Procurement information

Component price information, end-of-life (EOL) information, information about recommended alternatives to EOL components and multi-source information

6) Environmental response information

Response to the European RoHS regulations and information about controlled substances contained

7) Design information

Simulation information including SPICE models, IBIS models and thermal resistance

In this way, promoting component standardization and having timely registration of component-specific attribute information in the database to make it available to CAD and simulation is key to reducing development lead-time and ensuring design quality.

6. Engineering Cloud

FTCP, which has been described up to now, has been used internally in the Engineering Cloud environment since 2011 (**Figure 5**).[3] Engineering Cloud is a cloud environment centering on a desktop as a service (DaaS) environment intended for the field of engineering, in which screen data indicating the results of processing by the cloud are transferred to the client. High-speed transfer of large quantities of highly accurate image data of CAD and CAE is enabled by Remote Virtual Environment Computing (RVEC), high-speed display technology originally developed by Fujitsu.[4]

The following explains the major benefits obtained by shifting to the cloud.

1) Safe and secure environment available anytime, anywhere

The design and verification tools and design data that constitute FTCP are in the cloud, thus allowing the same design environment to be used anytime, anywhere. For example, it is accessible from various places such as offices, business trip locations, plants and homes. The design data are not stored on client PCs and are secure because their loss and theft is avoided.

The Fujitsu Group uses the cloud to apply FTCP to plants and repair bases as well as sites of development and has incorporated procedures, which were created in paper or PDF format, into CAD to improve work efficiency and reduce errors.

2) Facilitation of tool-data linkage

Electric and mechanical tools and their design data are consolidated in one location, which offers the benefit of ease of electric-mechanical linkage in a short TAT. Tasks that required design data to be gathered for each case in the past, such as checking on interference between components mounted on a PCB and a housing designed with mechanical CAD and

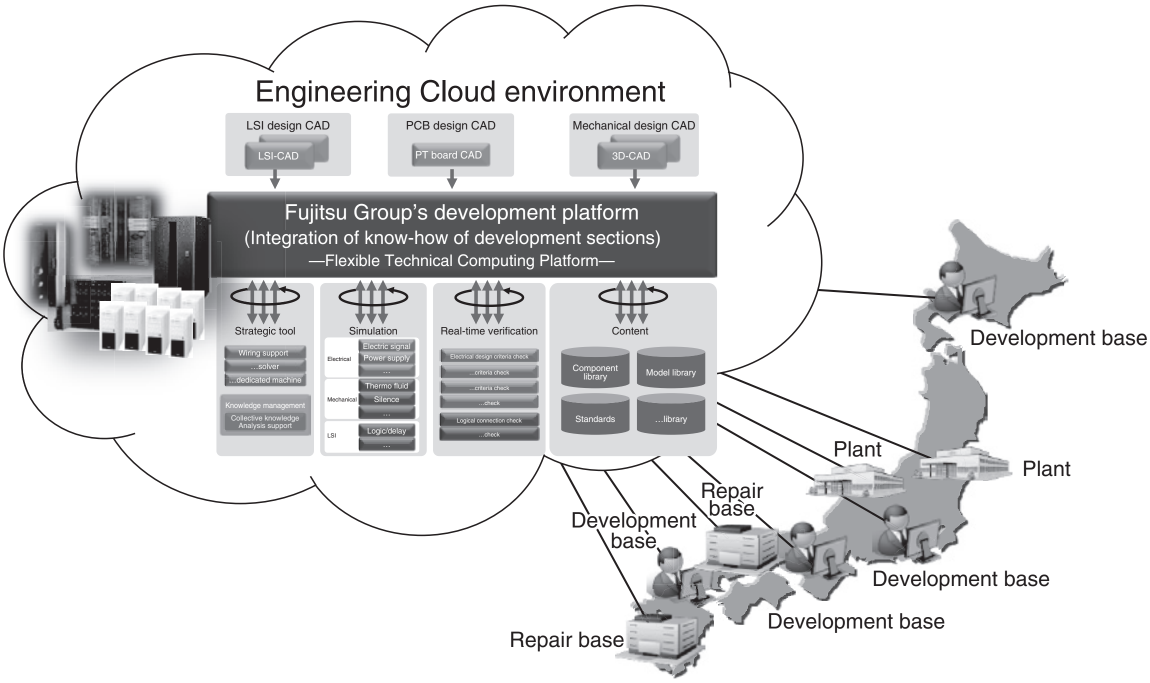

Figure 5
Application of FTCP by Engineering Cloud.

radiation noise analysis and thermal analysis of a PCB placed in a housing, can be immediately performed.

3) Inheritance of existing design environment

Engineering Cloud is characteristically capable of migrating the existing design environment as it is to a cloud by using the cloud platform. In the shift of Fujitsu’s FTCP to the cloud, the integrated environment built over many years has been successfully migrated to the cloud with the minimum cost.

Design environments currently used by customers probably have various types of know-how and system linkage incorporated. By putting them on the Engineering Cloud platform, they can be migrated to a secure and convenient environment with the minimum switching cost.

To take one step further, linking and partial integration with Fujitsu’s FTCP in a cloud will make available the standard component database, DRC incorporating the customer’s know-how and various simulation tools. For large-scale computer resources required for simulation, use of a data center only as much as required when required will allow the initial investment to be reduced and realize an efficient design environment.

7. Conclusion

This paper has presented electrical CAD, an electrical simulation environment and a component database that support them. They are key components of the electrical design platform that has brought together Fujitsu’s many years of know-how in *monozukuri* as an ICT enterprise. It has also explained that providing the platform internally via the Engineering Cloud environment brings further convenience and safety.

In addition, use of internal examples to take advantage of the Engineering Cloud platform technology also in customers’ design environments is believed to allow the current design environment to be migrated almost as it is to the cloud and merits of shifting to the cloud to be enjoyed at low cost.

We believe the key to strengthening the *monozukuri* of Japan in this age of global competition is to predict the future of technology and ICT environment that evolve on a daily basis and to continue to construct and maintain the most advanced design environment consolidating the company's core competency and know-how.

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