Architecture for Digital Technology Utilization to Accelerate Digital Innovation

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The spread of digital innovations that disrupt existing business models, such as Uber's ride-sharing service and Airbnb's short-term lodging service, has been accelerating. Against this backdrop, Fujitsu has started working on the co-creation of new businesses by combining the business know-how of customers and Fujitsu's digital technologies. For example, our co-creation work with TOMOE Corporation combines assembly know-how at manufacturing sites with augmented reality (AR) and other digital technologies to superimpose and display design drawings (3D CAD data) on steel frame components assembled on site, allowing early detection of defects and improving yields. In this way, we are working to deploy standardized business components that implement business know-how acquired through co-creation with customers, and design patterns created by combining such components on a platform built by integrating the cutting-edge technologies and the latest open-source software (OSS), in the form of cloud services. Incorporated into this is the business expertise we have accumulated through co-creation with customers. All the above helps accelerate the creation of digital solutions and the expansion of the digital domains of system integration (SI) in existing categories of business. This paper presents the approach by Fujitsu to the utilization of digital technologies.

1. Introduction

Recent advances in digital technologies such as IoT, AI, and robotics are contributing to the acceleration of digital innovation (digital transformation) to the point of severely disrupting existing business models of industries such as manufacturing and logistics. For example, the advent of Uber's ridesharing service, which uses GPS information to match a user who wishes for car transportation and a driver who wants to earn money using his or her car during idle time, has driven the largest taxi company in San Francisco to bankruptcy. In Japan too, the sharing economy, in the form of ridesharing services, private lodging services, car sharing services, and the like, is emerging, and the pace of digital innovation is accelerating.

The term "digital technologies" includes the nuance of cutting-edge technologies that bring about unforeseeable changes unlike conventional ICT developments to date. We call businesses that utilize such digital technologies "digital businesses," and business model innovations "digital innovation."

Through co-creation with customers, Fujitsu aims to create new digital businesses by accelerating the pace of digital innovation of customers. This paper introduces digital innovation-related issues that Fujitsu has encountered in our co-creation with customers, and our efforts to solve them.

2. Digital innovation trends

This section describes the status of digital innovation initiatives in the global market, the system construction process required for digital innovation, and examples of digital innovation initiatives and related issues.

2.1 Status of initiatives for digital innovation

Fujitsu conducted a "Global Digital Transformation Survey" targeting management and decision-makers (business leaders) in 15 countries around the world for the purpose of investigating the current status and trends in digital innovation, and released the findings of this survey in April 2017.[1] According to the results of this survey, 89% of business leaders around the world indicated that the companies and organizations they belong to begun activities for digital innovation. Further, such activities are not all in the initial study or trial stage; some have already reached the execution stage aiming for concrete results, and 34% of projects are already producing results such as sales increases and stronger relationships with customers.

2.2 System construction process required for digital innovation

The digital age calls for a system construction process that differs from the conventional system. In the Japanese market, the introduction and updating of the conventional system, systems of record (SoR), relied on a system construction process under which customers (business divisions and ICT departments) compile the system requirements and ICT vendors construct the system based on that.

By contrast, when the new system, systems of engagement (SoE), is introduced in the digital age, the process starts with the collection of information on how the changes in the environment of the customer's business affect it, and the identification of issues.

Based on the knowledge gained and the issues detected as a result, new business ideas are created. Then, actual services are quickly constructed and trialed, yielding know-how for the resolution of the issues, and course adjustments are made accordingly. To achieve this, a scheme that allows innovation in collaboration with customers' business divisions, ICT departments, and ICT vendors, along with fast execution of the above-described series of activities at high speed, is required.

2.3 Examples of initiatives aimed at digital innovation

To achieve digital innovation for customers, Fujitsu has carried out co-creation with customers utilizing digital technology. As a representative example, we introduce our initiative towards zero defects in the manufacturing processes of TOMOE Corporation, a company with a broad range of operations from general construction contracting to the construction of steel towers, bridges, and steel frames.[2]

TOMOE Corporation used to visually inspect assembled steel frame components to check their conformance with design drawings (3D CAD data), as part of the process of assembling manufactured members to build 3D structures. However, the detection of defects was difficult for anyone but experienced experts, and reducing risks such as rework and construction delays was a challenge. To resolve this issue, Fujitsu investigated the development of technology for the detection of defective products through the visualization of differences between the design and the actual manufacture by using smart devices to superimpose and display the 3D CAD data on the assembled steel frame components.

Yet in the way of such development stood two technological challenges that needed to be overcome. One was the fact that applying the markers to be used as reference was a laborious process. Fujitsu's existing marker type image recognition technology required the use of markers such as barcodes, QR codes, or augmented reality (AR) markers for position reference. However, the large number of steel frame components to be assembled made the cost of introducing and managing markers on steel frame components an issue, rendering realization difficult. The second challenge was the complexity involved in handling 3D CAD data. Superimposing and displaying the 3D CAD data onto the actual component on a smart device not only requires effort and time to manually adjust the position, the rotation angle, and the scale, but it is also extremely difficult.

To solve these problems, we developed a new technology that combines image recognition technology and AR technology. This technology matches the feature line segments of steel frame components recognized by image recognition technology from imaging data of these steel frame components captured with smart devices, with the feature line segments recognized by recognition technology from 3D CAD data, in order to detect information regarding the correct position, rotation angle, and scale for superimposition display, and thereby achieve usable superimposed display via AR.

The resulting accurate positioning of 3D CAD data on the assembled steel frame components allows identification of defective products at a glance. Traditionally, even in the case of inspection by an expert, it took one hour to inspect one steel frame component, which made it impossible to perform sampling inspection on more than about 10 parts a day, opening the door to the risk of defects in steel frame components not subjected to sampling. Actual use demonstration of the proposed technology showed that detection of a defective product could be done in just one to two minutes without resorting to the services of a professional, meaning that the shipping yield could be improved significantly (**Figure 1**).

Fujitsu provides the outcome of this co-creation as a product inspection service.

2.4 Challenges for the realization of digital innovation

Companies are increasingly working towards digital innovation, but it is a fact that Proof of Concept (PoC) tends to be a long process that rarely leads to the actual creation of a digital business. Thus there is a big gap between what a company wants to realize (its needs) and its realization means utilizing the latest digital technology (seeds).

As already mentioned in the previous section, in co-creation with customers, we have identified the following three gaps as issues that need to be solved (**Figure 2**).

1) The customer does not know which technologies to use to realize the idea for solving business problems, or else does not know how to use those technologies.

Digital innovation starts with the extraction of ideas for solving business problems. Familiarity with a huge amount of digital technology is required in order to determine the optimum approach to realize the extracted idea. Further, it is necessary to cope with the speed at which digital technology advances. Since the center of digital innovation is often the business division, the hurdles for technology application are becoming higher than ever before.

2) Even if an idea is implemented as a service, business needs cannot be satisfied by a single iteration. The desired outcome is attained only after multiple iterations.

Even if a company knows which approach should be used to realize a given idea, there are many cases

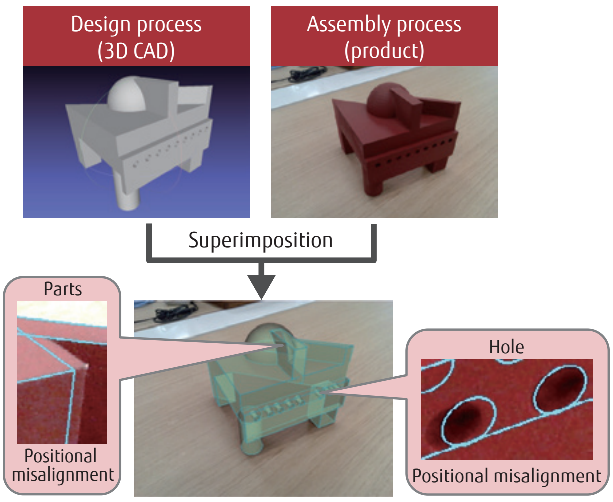

Figure 1
Example of co-creation with TOMOE Corporation.

	Challenges for the realization of digital innovation	Solutions
1	The customer does not know which technologies to use to realize the idea for solving business problems and how to use them.	Provision of shared functions (know-how) for industry and business as services ⇒ Use of design patterns and microservices that have been verified in terms of ROI
2	Since actual system verification takes time and money, efforts are abandoned before usable results are obtained.	Integration of technologies ⇒ Reduction of verification time and cost by utilizing technology integrating APIs that can be used to easily combine the required technologies
3	ROI is not clear, so introduction of digital technologies is not realized.	Business effect measurement APIs ⇒ Acquisition of business validity verification data using business effect measurement APIs to evaluate KPIs

API: Application programming interface KPI: Key performance indicator

Figure 2
Challenges and solutions for the realization of digital innovation.

where business needs cannot be satisfied without combining multiple technologies. For example, to respond to the need for automated judgment and action at a site, in addition to the visualization of the information required for judgment and action, a number of technologies such as for data collection, data cleansing, analysis and prediction, must be combined. Moreover, to reduce the gap between needs and seeds, multiple iterations and verifications are needed. Since service implementation and system building take time and money, such efforts do not always lead to service delivery.

3) Because, on the business side, return on investment (ROI) cannot be verified, the introduction stage sometimes fails to be reached.

Even when it comes to implementing services that meet business needs, it may not be possible to measure and verify ROI, so the required approval may not be granted and full-scale introduction may never occur.

3. Fujitsu's approach to tackling challenges

This section describes our activities to use digital technology to tackle the challenges mentioned in the preceding section.

3.1 Architecture for digital technology utilization

To bridge the gap between a company's needs (what it wants to realize) and seeds (digital technologies) mentioned in the preceding section, we designed a new cloud service architecture for the utilization of digital technology. This architecture makes it possible to use APIs that mash up component technologies and APIs that can be utilized as solutions for actual business. This enables companies to realize and demonstrate what they want to realize in a short time.

The three main features of this architecture are described below (**Figure 3**).

1) Creation of shared functions (know-how) across multiple industries/businesses as services

Fujitsu implements the industry and business expertise it acquires through co-creation with customers as standardized business components and provides design patterns that combine these components as services. The use of design patterns makes it possible to apply digital technologies even when the customer does not know how to realize the idea. The use of design patterns whose effectiveness has been verified in terms of ROI through co-creation with customers solves the problem of customers not being able to arrive at the technologies and implementation approaches required to realize their ideas.

For example, in the case of the aforementioned

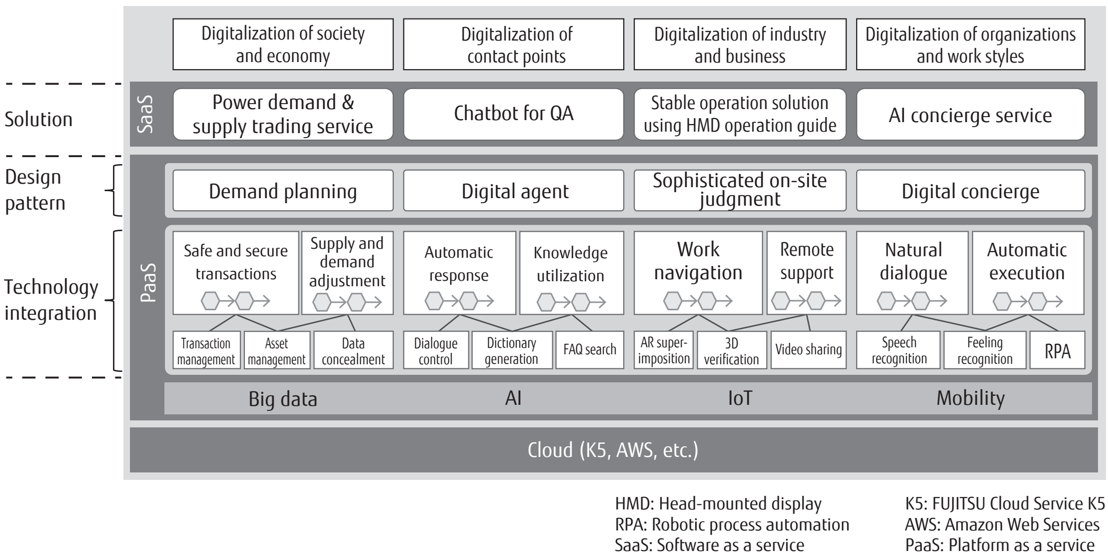

Figure 3
Architecture for digital technology utilization.

product inspection support service, a function that visualizes manufacturing errors by superimposing 3D CAD data of a design drawing on the manufactured product (design pattern) made it possible to quickly develop a prototype of the idea of "superimposing design drawings on assembled steel frame components."

2) Technology integration

Fujitsu provides APIs that mash up our own technologies, the latest open-source software (OSS), and independent software vendor (ISV) technologies. Until now, to utilize a combination of several technologies, it was necessary for an application developer to verify the respective component technologies and develop ways to combine them. By providing these technologies as an API that combines the component technologies in a way that has been tested to work, the respective technologies are concealed and it is possible to achieve implementation in a short period of time and at low cost.

For example, in the case of the aforementioned product inspection support service, four technologies are provided as APIs that have been tested to work together, allowing prototype development and verification at an early stage. These four technologies are recognition technology for captured images (2D image data), 3D CAD data recognition technology, feature line detection technology that can detect feature lines from captured images and 3D CAD data, and AR technology that verifies and matches detected feature lines to superimpose design drawings on assembled steel frame components.

3) Business effect measurement API

We provide APIs developed through co-creation with customers for the evaluation of KPIs required for the verification of business effect. By using design patterns whose effectiveness has been verified through co-creation with customers, customers are able to use the ROI verified in earlier cases, and utilize the APIs for their company's business.

For example, in the above-described product inspection support service, it is possible to calculate the business effect from information such as the yield, number of inspections, and number of defective items, which are important factors to consider in the product inspection process.

3.2 Technical requirements

This subsection describes the technical challenges in realizing the architecture described in the previous paragraph.

1) Secure the reliability of the whole service

When multiple services are used in combination, it becomes difficult to secure the reliability and availability of the whole service. The failure or suspension of even a single of the constituent services directly causes the suspension of the whole service, and ensuring the quality of the whole service is essential, yet this is difficult to achieve since the constituent services come from various providers. Further, to ensure continuous service provision, it is necessary to perform switching when there is a problem with a given service and/or provide multiple versions of the same API.

2) Labor saving for service definition and editing

To develop applications at the lowest possible cost while minimizing the development period, it is necessary to have a system that allows use/adaptation of existing APIs and their construction based on definitions without the need to develop APIs from scratch.

3) Support of media data

Going forward, as device performance grows ever higher and networks grow ever faster, use of video, audio, and other media services in addition to sensor data, is expected to expand greatly for such things as environmental monitoring and flow line monitoring at stores using cameras. However, as video and audio are continuous streaming data, they are difficult to handle. Building applications that handle video and audio requires dedicated technology and environments.

4) Operation in multi-cloud environment

Operation in the cloud environment specified by the customer may be required. To achieve cooperation and coexistence with existing systems, a configuration that does not depend on a specific cloud environment must be used.

3.3 Technology development to meet technical requirements

The structure of this cloud service, capable of meeting such technical challenges, is described below (**Figure 4**).

The main constituent parts of the cloud service are the Core Technology part, which provides value by mashing up core technologies, the API Governance

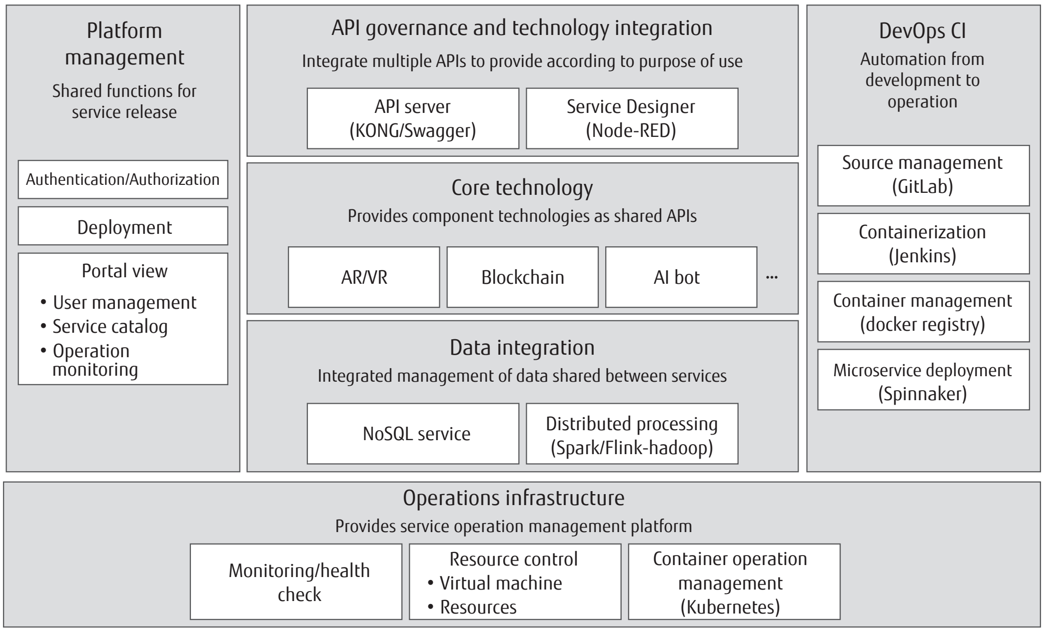

Figure 4
Outline of configuration of cloud services for digital technology utilization.

part, which provides integrated access through a combination of managed APIs, and the Data Integration part, which carries out integrated management of data. Because the APIs of these three main constituent parts are what achieves differentiation from other companies, we will actively develop them to create new businesses through co-creation and PoC with customers.

We have a service platform for DevOps that offers operation, development, and service release functions as an infrastructure component that supports the three main constituent parts. This infrastructure component is designed to actively improve efficiency by making use of OSS.

The features of this cloud service, capable of meeting technical challenges, are described below.

1) Building block method and operation monitoring to ensure service reliability

The cloud service provides component technologies such as AR, virtual reality (VR), and blockchain, as shared APIs, using the building block method. Individual component technologies are made independent as independently operating services (microservices), and these services are combined to provide new services. This makes it possible to flexibly support the latest OSS technologies as well as combinations or permutations with other companies' technologies. Further, this makes switching possible when a given service develops problems, as well as supporting the provision of multiple versions of the same API. Moreover, to ensure overall reliability, this supports also health checks for each service, round-the-clock performance monitoring, and service operation management for quality control through resource control of the whole service.

2) Service Designer for realization of quick and flexible service definition and editing

The cloud service provides a development and execution environment (Service Designer) that can define using graphical user interface (GUI) arbitrary services as a flow that combines various APIs (**Figure 5**). Service Designer makes it possible to respond promptly to requests for business application or business expansion according to business requirements in a manner that does not require programming. It allows also the accumulation and reuse of service flows as templates. In addition, as a mechanism for flow management, it supports version control, backup, rollback, authentication for operation management, and multi-tenancy.

3) Real-time media platform

The service realizes a system that, using service flow definitions only, allows easy service construction

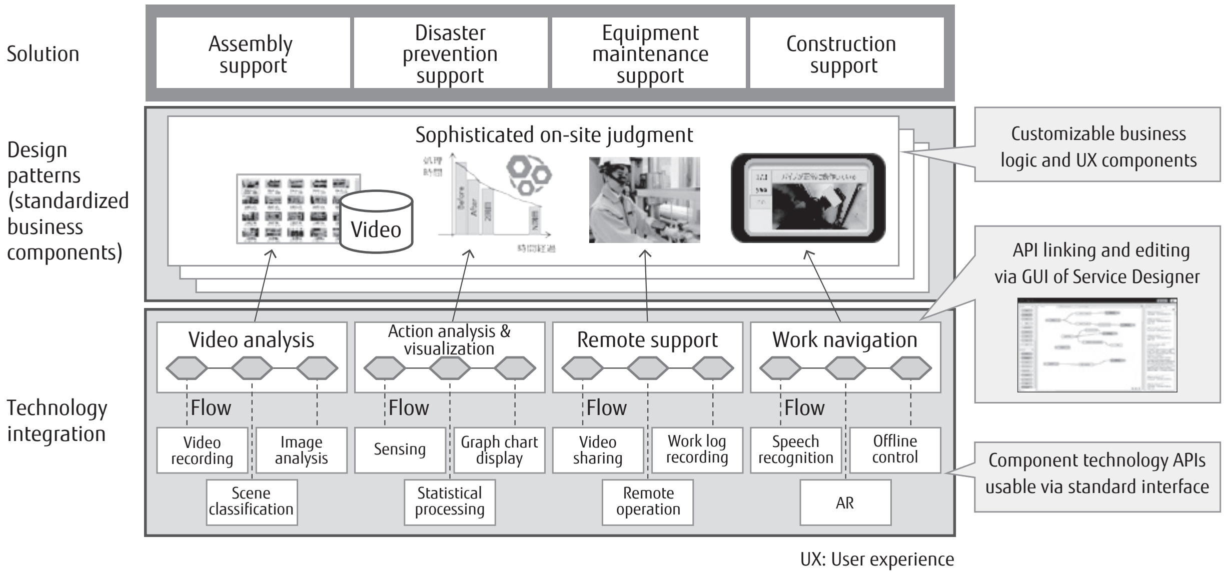

Figure 5
Service Designer and service flow.

and release for the purposes of video and audio media processing. To support streaming data, it provides functions such as video sharing and audio mixing capable of sequential processing of video and audio data in real time. Video and audio data processing can be divided into the independent processes (filters) of "image capture/audio recording," "recognition/analysis," and "distribution/recording," and services can be described by combining filters. In addition, since the filters are all independent, they can be flexibly recombined, for example to replace the current recognition rate with a higher recognition rate.

4) Container structure operating in multi-cloud environment

The service was built on the highly reliable FUJITSU Cloud Service K5 platform. The individual service components are containerized using Docker to minimize dependence on the environment. As a result, it can operate not only on FUJITSU Cloud Service K5 but other cloud platforms too.

4. Conclusion

This paper introduced Fujitsu's approach to utilize digital technology to accelerate digital innovation.

The introduced technologies are a springboard that will accelerate the creation of digital solutions for solving on-site issues by harnessing the power of digital technology through co-creation with customers. In addition to integrating cutting-edge digital technologies, we also provide, as a cloud service, design patterns (standardized business components) that make use of business expertise that, in the process of co-creation with customers, has been proven to achieve an ROI.

We are convinced that by using this cloud service, customers will be able to fill the large gap that exists between needs (what they want to realize) and seeds (digital technologies) as they carry out digital innovation. We plan on continuing to enhance the lineup of design patterns (standardized business components) and further refine them to better contribute to the digital innovation of our customers.

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