Future Trends in Software Technology to Support Digital Innovations

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Customers' new digital businesses are heading toward business-to-business (B2B) digital co-creation, where a large number of service users are linked with a large number of service providers through digitalization. The digital co-creation space will become a connected world in which necessary information is exchanged for individual business purposes beyond the borders of any one category of business or industry, and will expand as an ecosystem. In this connected world, for both service providers and users to conduct business in a stable manner, various technologies will be required to provide a system that allows for easy participation by both parties with a sense of security to maximize the value and convenience that can be enjoyed by the two parties and end users. The key factor in the process is the wide variety of data, which is to be handled differently according to customers' systems. Combining this data based on business purposes and agreements to convert them into connectable information that is worth analyzing and utilizing for distribution can lead to the creation of new businesses and services, or digital innovations, as well as lead to economic and industrial growth. This paper presents trends in software technology related to the realization of these and Fujitsu Laboratories' activities.

1. Introduction

Cyber-physical systems (CPSs), which use IoT to digitalize (make into electronic data) the real world for analysis, prediction, and improvements in efficiency, are recently attracting attention. For example, the provision of instructions for improving lifestyles and health by using wearable devices, monitoring for troubles in various structures, and life cycle management based on the location and operational status management of products are spreading into various environments including our daily lives, society, and the economy.

Customer companies are aiming to succeed in the individual categories of business and operations through an ecosystem by utilizing open-source software (OSS) and other means to make their strengths, which have been digitalized through IoT, AI, and other digital technologies, into platform services. In that space, platform services are provided to connect things for digitalization and analysis. Value will be added by connecting users and providers of various services, and business-to-business (B2B) digital co-creation will be enclosed in an ecosystem. What is more, service platforms that realize such B2B digital co-creation will be connected for individual business purposes beyond the borders of any one category of business or industry, and information necessary for business will be exchanged.

Based on a survey conducted of executives from over 1,000 large companies and start-ups respectively in G20 countries,[1)] an increase in digital collaboration is reported to potentially raise global GDP by almost 1.5 trillion dollars, or 2.2% of world output, and bring a growth opportunity of 94 billion dollars to Japan, or 1.8% of its GDP. A survey conducted by Fujitsu[2)] of 1,614 executives in 15 countries has also revealed that 89% of business leaders are executing, trialing, or planning various digital transformation projects, and 34% of those projects have already delivered positive outcomes. In this way, a "connected world" is already beginning to expand globally, including among real business.

In the future, a connected world will develop where services integrating people, things, and ICT will work in harmony with people concurrently,

autonomously, and interactively to assist with activities and the value and convenience enjoyed by parties including end users can be maximized (**Figure 1**), rather than where people adapt themselves to and master devices and machines as is true today. To that end, at Fujitsu Laboratories, we consider the following three conditions as necessary.

1) The digital world becomes a part of daily life and society, causing people, machine, and service processes to be dynamically connected in an environment where data to be handled are omnipresent.
2) In order for the real world to be reflected in the digital world more precisely and in real time to accurately grasp it, the types, quality, and quantity of data to be handled–including audio and visual data–will increase. Learning, prediction, and adaptation will take place concurrently, autonomously, and interactively for a variety of purposes.
3) Improvements in quality and quantity of services that assist the real world will become possible.

The key factor in this connected world is the wide variety of data, which is to be handled differently according to customers' systems. These data can be combined based on business purposes and agreements to be converted into "connectable information" that is worth analyzing and utilizing for distribution. This can lead to the creation of new businesses and services, or digital innovations, as well as lead to economic and industrial growth.

This paper presents trends in software technology related to the realization of the above-mentioned world as well as Fujitsu Laboratories' activities.

2. A world that produces digital innovation

In the connected world described earlier, it is necessary is to find services that not only satisfy the functional and non-functional requirements but which also can be used with a sense of safety and security from the services provided by various systems in existing business domains. In addition, after the user and provider have come to an accord and appropriately concluded an agreement, adjustments must be made to allow connections between application programming interfaces (APIs) and between data. Therefore, in order to give shape to and realize these as an ecosystem, Fujitsu Laboratories is considering the creation of a reference model for sharing concepts, terms, and technologies between companies, or stakeholders.

This reference model consists of seven layers as shown in **Figure 2**. The Connected Information layer in the middle of the figure is a layer at the core of this model that allows services in different domains to be connected based on the agreement between the service provider and user. In layers lower than this, data stored in conventional ICT systems not yet in forms allowing for connections and data gathered from people, things, and events in the real world are sent to the Connected Information layer via three layers (the Physical, Physical-Virtual, and Communication layers).

Meanwhile, the Business layer at the top is a layer for managing services to be offered to end users by managing workflows that realize services. The Orchestration layer is responsible for the call control of functions constituting a workflow (workflow execution control), and various functions are executed by using connectable information in the Function layer. At this

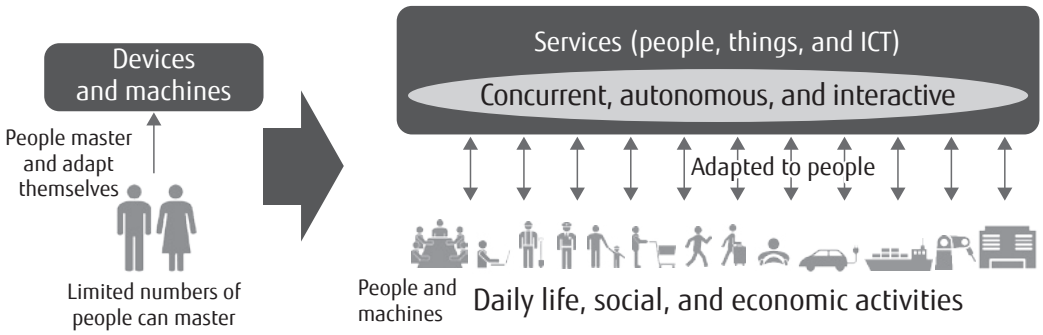

Figure 1
Future connected world.

time, function execution and data access are controlled in the Function and Connected Information layers according to the policies based on the agreement in the Business layer.

For example, in order to extract combinations of appropriate services that can be used with a sense of safety and security, the Business layer is provided with a service rating function for evaluating services and a service matching function. In addition, in the Orchestration and Function layers, APIs provided by various companies are used to make functions available for selection. In this way, technical problems can be solved using technologies provided in the layers in this model that satisfy the following requirements.

1) Digitalization of real world events
2) Guarantee of availability of services with a sense of security
3) Integration of physically and logically dispersed data for the release of connected information to users within the scope of agreement
4) Retrieval of optimum services satisfying requirements from among many services
5) Coordination between APIs with different syntaxes and semantics

The "Digitalization technologies" subsection in Section 3 details 1). For 2) and 3), an explanation is given in the "Data utilization platform technologies" subsection and 4) and 5) in the "Software development technologies" subsection.

3. Software technologies to support digital innovation

3.1 Digitalization technologies

This section describes digitalization technologies in the real world, which are important for realizing a connected world and creating digital innovation.

A person utilizes various senses, including the five senses, to capture information in the real world, and combines it with other knowledge and information to create value and make judgments and take action. In the same way, conditions in the real world surrounding people can be captured and imported into the digital world by analyzing and converting sensor data obtained from various IoT devices and audio, visual, and other media data. This is combined with other digital data to create value, which is achieved by digitalization technologies.

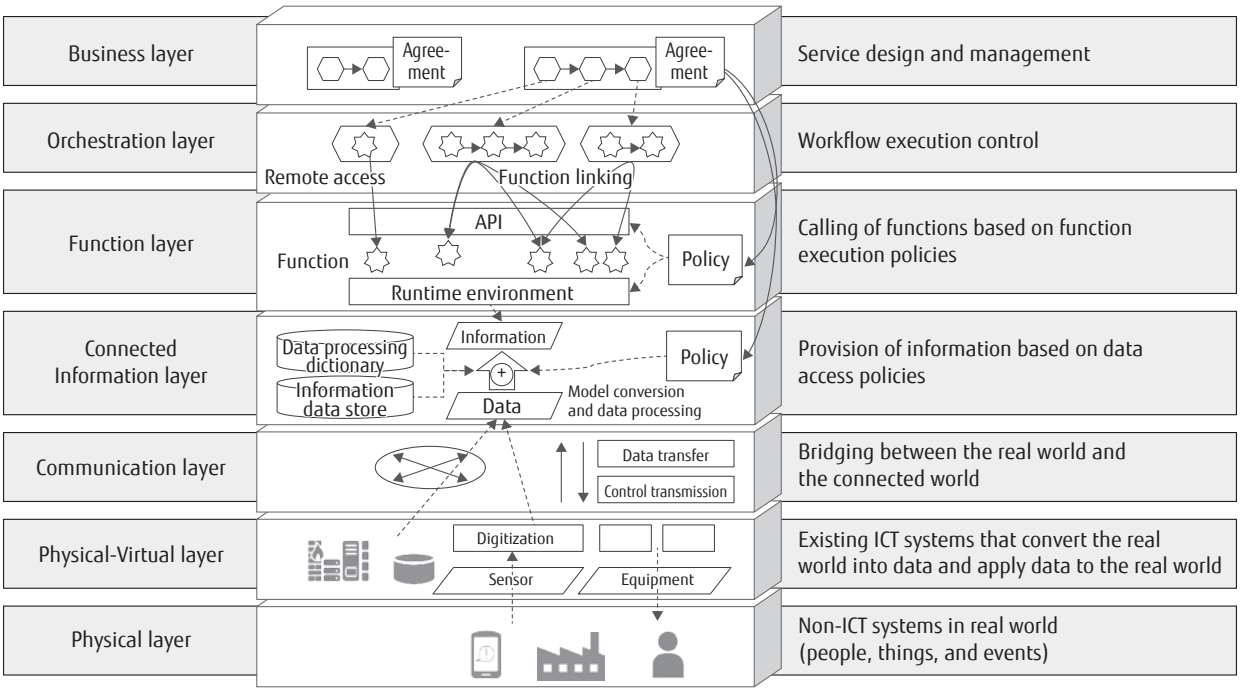

Figure 2
Reference model.

Of the digitalization technologies, Fujitsu Laboratories has been working on research and development of media processing technology over the years. For example, we have developed unique technologies such as a technology for extracting information not visible to the human eye via image analysis to use for digitalization[3)] and a technology for capturing objects in three dimensions from multiple images to use for searching.[4)]

Up until now, media processing technology has often been incorporated into systems and products to be put to practical use for specific applications. However, in the future, to realize a connected world, development should be directed toward the achievement of technologies with higher versatility and flexibility that are applicable to a variety of scenes. Development should then be aimed to realize platform technology capable of real-time digitalization of large volumes of media data, which are scattered physically or logically and generated from moment to moment, to combine them simply and flexibly with other digital data to create value. This requires a media processing API service executed in an environment not confined to the cloud.

3.2 Data utilization platform technologies

This subsection describes data utilization platform technologies for creating and utilizing connectable information, which provides the key to connections between services in different domains.

Conventionally, services and the customer data that connect them were designed for each system and were not only stored in geographically distant places but also involved various data structures and meanings. Accordingly, data linking required the individual development of data processing, conversion, and transfer with clearly defined purposes for connections.

In a connected world, however, dynamic digital co-creation across different categories of business takes place, which means how data is used cannot be designed in advance. For that reason, the provision and utilization of data requires the concept of a flexible processing platform based on data. In addition, agreements and rights-related issues between data providers and users become more complex, which creates the need for a system of monitoring and controlling access to connectable information. Furthermore, obtaining connectable information requires the activation of a service based on changes in the real world that are made into electronic data one after the other.

To realize these, Fujitsu Laboratories proposes a data utilization platform called Data Bazaar, which is shown in **Figure 3**, to work on research and development in the following fields of technologies characteristic of data utilization.

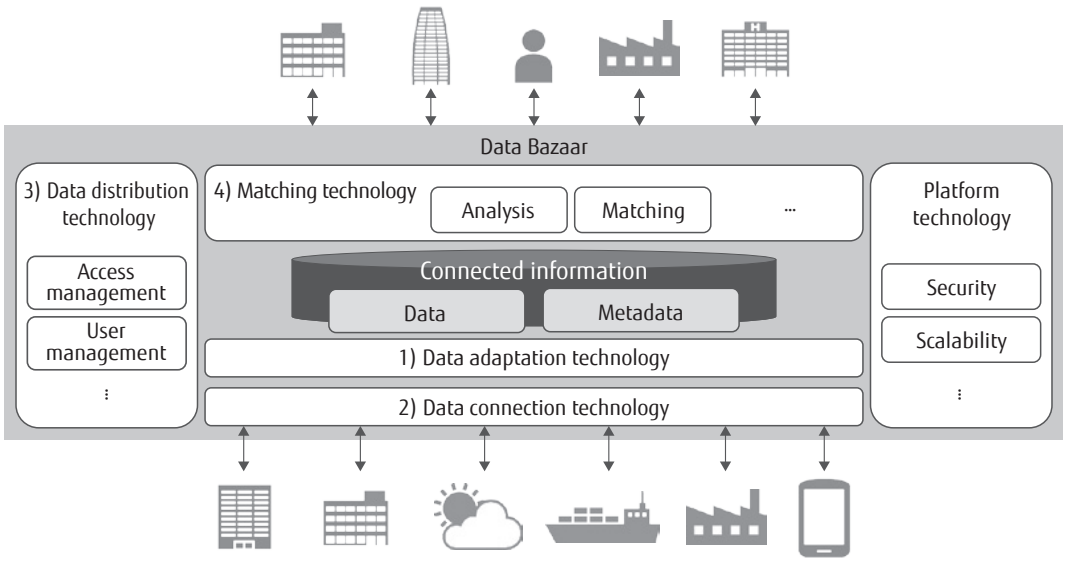

Figure 3
Data utilization platform via Data Bazaar.

1) Data adaptation technology

Access to the original data is abstracted to realize information extraction and management of data that make the data location, format, and structure transparent to the user. To minimize the transformation burden required for this information extraction, new data processing technology is necessary. The task of integrating data formats and structures was conventionally referred to as data preparation, which often involved manual labor and posed the issue of accounting for as much as 80% of the processing time for data utilization. To deal with this, Fujitsu Laboratories has developed a technology that makes use of automatic programming technology and machine learning[5] to automate the transformation process.

2) Matching technology

Connectable information, continuously generated on Data Bazaar, is provided with metadata that store data attributes to make it easier for data users to find and utilize the information. We realize management of this metadata and fuzzy matching and search functions to make it easier for data users to find the information they need.

3) Data distribution technology

In addition to data access control and user management, access history–which is generated in large volumes–is managed to realize data tracking and origin management. Furthermore, the trail function preventing alterations even by the platform operator and the function for retrieving necessary trails allow the acquisition of reliable data distribution logs to realize safe and secure data distribution.

4) Data connection technology

An event-driven data processing platform capable of following the conditions of individuals and companies that change moment by moment in order to activate a service by using a change in the conditions as a trigger is required.

In addition to the technologies mentioned above, we move ahead with research and development for the Data Bazaar technology while making use of the data processing acceleration and security technologies we have developed up to now to realize the data utilization platform from the Communication layer to the Connected Information layer.

3.3 Software development technologies

This subsection describes the software development technologies intended for applications to realize services in the connected world presented earlier.

Conventional enterprise systems employ scratch development, or development from scratch according to business requirements, or waterfall development of applications based on package software. Meanwhile, in the digital innovation domain, an agile development process is employed in which a prototype is quickly developed from ideas in the initial planning phase, followed by testing and small-scale releases (**Figure 4**).

There is also a significant change in the target of development. Conventionally, the target was business transaction processing for the web three-tier system (PC, application server, and DB server). In the future, the target will be processing combining internal and external APIs provided in the Function layer, as shown in Figure 2. Accordingly, utilization of the functions and data provided by others based on a sound understanding of their quality is required.[6] At Fujitsu Laboratories, we have already developed a technology for partitioning functions of internal systems to make them into APIs.[7] But to make use of functions provided externally, the following requirements must be satisfied, as explained in the previous section.

- Retrieval of the optimum service satisfying the requirements from among many services
- Coordination of APIs with different syntaxes and semantics

In order to realize these, we are working on research and development by classifying software development technologies into the three perspectives shown in Figure 4: "searching" and "connecting" in the development process, and "maintaining" in the operation and maintenance process.

1) Searching

Searching refers to easily finding necessary functions and data according to the requirements.

A function that recommends appropriate API types based on keywords is already offered.[8] However, there is no system available that offers information necessary to developers in a timely manner, such as adequacy of the documentation and samples of each individual API and its performance in actual operation.

2) Connecting

Connecting means assembling different functions

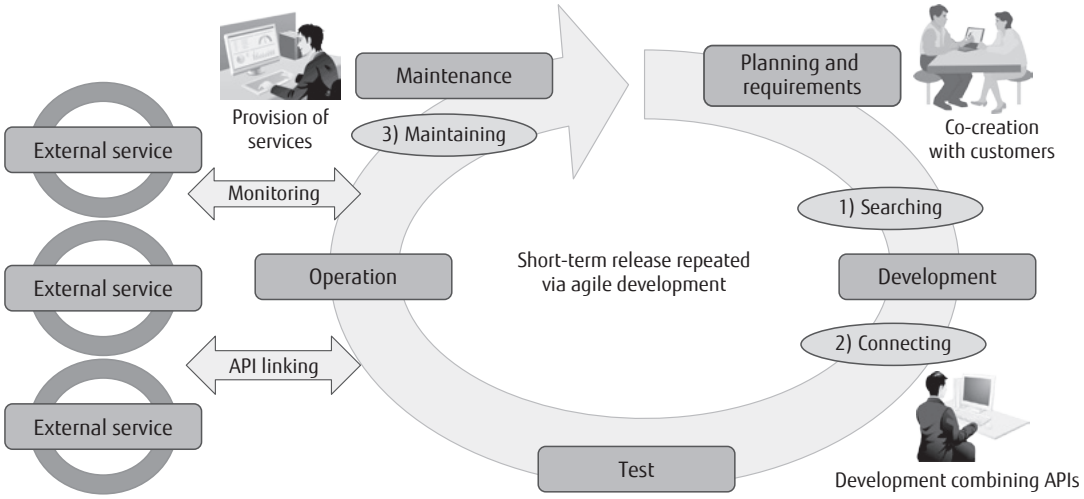

Figure 4
Software development life cycle.

and data easily.

At present, there is no industry standard for API functions. Development by combining multiple APIs requires developers to create them individually according to the differences in the authentication method, communication protocol, and data format.

3) Maintaining

Maintaining means quickly complying with any changes made to the software created by others.

After the operation of a service is started, any changes made to the specifications of the API called must be dealt with each time by the developer making modifications to the application. The man-hours required for the repairs pose an issue.

To resolve these issues, we are working on research and development of a system that automatically and regularly collects the individual API specifications to visualize or absorb differences between them. By realizing this system, the application development and operation cycle can be sped up to accelerate digital innovation.

4. Conclusion

This paper presented trends in software technology for realizing a "connected world" in which necessary information is exchanged across different categories of business and industries as well as Fujitsu Laboratories' activities.

In the future, we intend to continue to aim for the realization of an ecosystem in the connected world through digitalization technology by utilizing information, including that acquired by sensing human emotions, to create digital innovation, data utilization platform technology for real-time conversion of events that occur in the real world into connectable information, and technology for developing software that supports digital innovation.

References

1) Accenture: Harnessing the Power of Entrepreneurs to Open Innovation.
https://www.accenture.com/t20151005T162506__w__/us-en/_acnmedia/Accenture/next-gen/B20/Accenture-G20-YEA-2015-Open-Innovation-Executive-Summary.pdf
2) Fujitsu: Digital transformation delivering business outcomes.
http://www.fujitsu.com/sg/microsite/vision/insightful-stories/survey1/
3) Fujitsu: "FlowSign Light" used in "TV Asahi, Roppongi Hills summer festival SUMMER STATION" (in Japanese).
http://pr.fujitsu.com/jp/news/2017/07/14-1.html
4) Fujitsu Laboratories: Fujitsu Develops AI-Based Technology to Retrieve Similar Disease Cases in CT Inspections.
http://www.fujitsu.com/global/about/resources/news/press-releases/2017/0623-01.html
5) Fujitsu Laboratories: Fujitsu Automation Technology Preps Data to Accelerate Analysis.
http://www.fujitsu.com/global/about/resources/news/press-releases/2017/0915-01.html

6) R. Yamamoto: The Role of Software Engineering in Japanese Industry. Information Processing, Vol. 58, No. 8, pp. 682–683 (2017).
7) Fujitsu Laboratories: Fujitsu Develops Technology to Partition, Visualize Complex Business Application Structures by Function.
http://www.fujitsu.com/global/about/resources/news/press-releases/2017/0518-01.html
8) IBM: API Harmony.
https://apiharmony-open.mybluemix.net/public

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