

2018 Summer

Knowledge Integration for the Future



Clear the Way for Your Future on a Digital Journey

Part 1 Readiness and Exposure towards a “Digital Journey”

Bring the Knowledge Integration into shape

Part 2 Evolving the “Service Framework for Co-creation”

Continually innovate the “Co-creation” approach through implementation with customer

Part 3 Solutions & Technologies

Necessary digital technology to know and solution from Fujitsu of AI, Annealing, etc.

FUJITSU



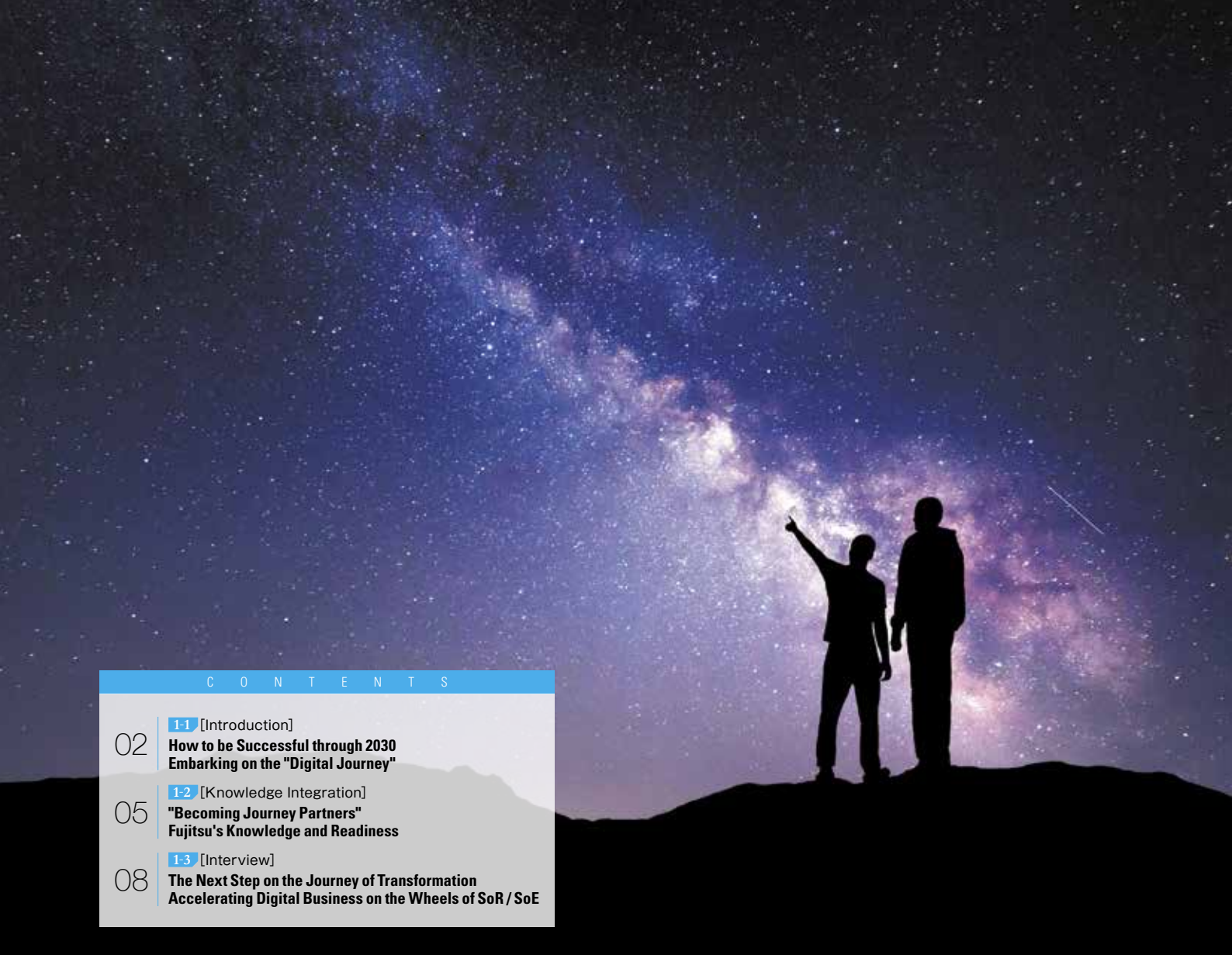
Knowledge Integration for the Future

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C O N T E N T S

Clear the Way for Your Future on a Digital Journey

- 01** **PART 1** **Readiness and Exposure towards a "Digital Journey"**
- 02 [Introduction] **How to be Successful through 2030
Embarking on the "Digital Journey"**
- 05 [Knowledge Integration] **"Becoming Journey Partners"
Fujitsu's Knowledge and Readiness**
- 08 [Interview] **The Next Step on the Journey of Transformation
Accelerating Digital Business on the Wheels of SoR / SoE**
- 12** **PART 2** **Evolving the "Service Framework for Co-creation"**
- 13 [Overview] **Deepening & Expanding the "Service Framework for Co-creation"**
- 16 [Gathering of Information] **Europe and America, China, Asia, Israel...
Directly Experience the Movements of Our World**
- 21 [Idea Creation] **Opening Doors with Learning and Practical Training
5 Points to Practicing Idea Creation**
- 26 [Lean Startup] **Organization, Contracts, and Personnel Needed for Agile Development**
- 31 [Column] **Example of System Framework for Co-creation in Practice
Efforts for Business Transformation with a European Oil Company**
- 33** **PART 3** **Solutions & Technologies**
- 34 [Overview] **Understanding the Digital Technologies
Required for Our Journey**
- 37 [Data Lakes] **"Data-driven Business"
Accumulating and Utilizing Big Data5**
- 42 [Artificial Intelligence] **Practical Use of the Zinrai Artificial Intelligence API
Digital Innovation via Co-creation with Client Companies**
- 47 [Chatbots] **Using AI to Revolutionize Customer Contact Points
and Prioritizing Utility with CHORDSHIP**
- 52 [IoT] **Wireless Technology Spreading in Response to Needs
and the Steady Evolution of Edge Computing**
- 57 [Cyber Security] **Japanese Companies Recognizing
the Impact of "NIST SP800-171"**
- 62 [Next-generation Computing] **In the World of R&D Advancements in Next-gen Computing,
What is the Potential of Combinatorial Optimization Using Annealing?**
- 67 [OSS] **OSS-driven Technology Trends
involving Accelerating Service Development**



C O N T E N T S

02	1-1 [Introduction] How to be Successful through 2030 Embarking on the "Digital Journey"
05	1-2 [Knowledge Integration] "Becoming Journey Partners" Fujitsu's Knowledge and Readiness
08	1-3 [Interview] The Next Step on the Journey of Transformation Accelerating Digital Business on the Wheels of SoR / SoE

PART 1

Readiness and Exposure towards a "Digital Journey"

Changes in social and economic environments,
along with the evolution of digital technologies are progressing at a high speed
that has never been seen before and is expected to continue.

If the company agrees with this hypothesis, then the only possible step is to embark on the digital journey.

Let us explain by advocating "Knowledge of Integration"
and communicating the seriousness of the challenge in detail, Fujitsu can be a key partner for this journey.

How to be Successful through 2030 Embarking on the "Digital Journey"

Jun Taguchi General Manager, IT Leaders Editorial Department, Impress Corporation

Mobility in 2030

Following the lift of the ban on self-driving buses and trucks on the highway, self-driving vehicles on public roads are also now legal. While there are still privately-owned cars, there is a move towards ride sharing, using vehicles such as Toyota's e-Palette (Fig. 1). While there are parking areas in cities for shared vehicles, decreasingly there are less profitable car dealers and service stations without charging stations, along with related businesses such as car supply stores. Housing prices near train stations have also dropped dramatically. However, while it might be expected that e-Palette vehicles making home deliveries via the internet would put convenience stores in jeopardy, that has not happened. If it is only a few hundred meters away, it has been found that people will still walk.

Durable Goods in 2030

How many years has it been since air conditioners and refrigerators went off the market? Major air conditioner manufacturers state "We do not sell air conditioners. We provide clean air," and they transition to using metered billing. While it is cheaper to buy a new unit every three years, companies guaranteeing to replace systems before they break down have become a welcome service in light of the recent hotter summers and harsher winters. Refrigerators have also adopted these metered rates. While it would be nice if washing machines did as well, the challenge is the variance in usage from person to person. Although they are not appliances, chairs are also now pay-as-you-go. Though a bit of a mixed blessing, they will alert you when you have poor posture.

Finances in 2030

Now, physical currency is seldom used. Virtual Digital Assistants (VDA) with integrated smartphones and smart speakers are used to make all payments and settle accounts. Blockchain has spread since 2020, and having been made ubiquitous through Fintech, now internet companies and normal corporations all use payment services.

The old idea that "banking is necessary, banks are not" has become reality. Several of what were known as megabanks and local banks have been restructured working in new lines of business. In the securities business, robot advisers using AI play a lead role, and the insurance industry has also changed as a result of the Internet of Things.

Over the next 12 years, just how might society, businesses, and people change? Though I do not have the most vivid imagination, I think it will resemble the above. Of course, this will not be the whole of it. While Japan has a declining birthrate and a growing proportion of elderly people, population worldwide is on the rise. Every year, each country's politics, economy, and climate, as well as the circumstances surrounding their energy and food, can be seen to fluctuate to greater degrees. We truly live in a VUCA World (see explanation at end of article), and the future cannot be clearly seen.

The Cloud, Mobile Devices...

Looking back on changes in the past 12 years

More than ever, digital technology has had a massive impact. Let's consider the events of the past 12 years, starting in 2006. In July, Amazon Web Services' (AWS)

cloud services went live. As is widely known, the service proliferated rapidly, and in 2017, had sales reaching \$17.5 billion (¥1.8 trillion). In June 2007, the first generation



Fig.1: At CES held in the U.S. in January 2018, the e-Palette concept car for mobility uses was announced by Toyota. The image shows it being used for ride sharing, but it has great potential versatility.

Source: <https://newsroom.toyota.co.jp/jp/corporate/20508200.html>

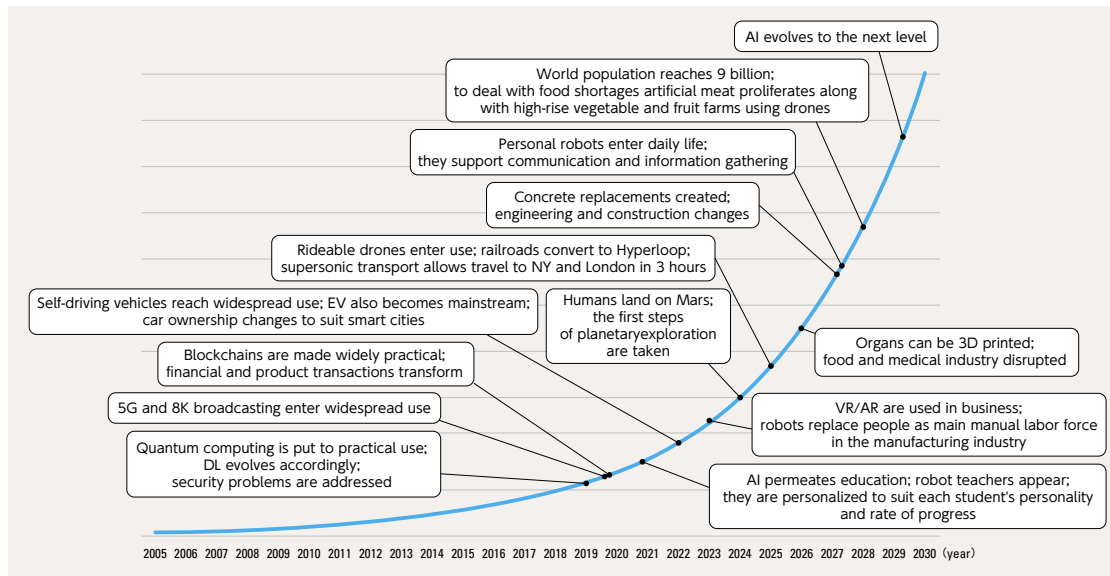


Fig.2: Technological advancements predicted to occur by 2030 and likely effects

iPhone released in the USA. A year later, the iPhone 3G was released worldwide, including in Japan, and at the same time, a multitude of Android-powered smartphones began to appear.

Along with the advent of platforms like the cloud and new mobile devices, start-ups began to engage in a number of disruptive activities. American DVD rental service Netflix launched its video streaming component in 2007, and at current, has become the largest such service with 100 million subscribers worldwide. They are also famously a prominent user of AWS. In 2008, American room-share service Airbnb debuted, and in 2009, American ride-share service Uber began full-scale operation.

The third AI boom was also brought on at this time with the development of Deep Learning. After the proposal of neocognitron by Kunihiko Fukushima in 1979 in Japan, there was a metaphorical long winter where computer performance failed to catch up to theory. Spring finally began to arrive in 2006, when British-born researcher Geoffrey Hinton proposed the method that led to present DL techniques. In 2012, he led a team that won a contest focused on AI object recognition, and with that DL was thrust into the limelight. Since then, its use has had significant influence on R&D in various fields with AlphaGo defeating a human go champion, advancements

in medical diagnostic imaging, self-driving vehicle technology, and so on.

Implementation of 5G and Automated Driving The next 12 years promise bigger changes

Over the past 12 years, it is easy to see how technology has evolved with surprising momentum. It cannot be overlooked that over the next 12 years (and likely beyond) that there is a high chance that this momentum will continue (Fig. 2). Although existing computer technology is approaching its physical limits, improvements in effective performance will continue to be made in aspects such as architecture and parallelization.

At the same time, R&D of quantum computers that operate under different principles is progressing, and by focusing on the combinatorial optimization problem, computers are being developed that are expected to become 10,000 times faster than existing models (see Part 3-7). In the near future around 2020, 5G wireless networking and high-definition 4K and 8K broadcasting will come into regular use.

Smart devices utilizing 5G ultra-high speed (large capacity) wireless networks operating at 10Gbps in particular are highly likely to fundamentally change the

IoT, vehicles, and the roles of digital devices in general. With all these various technologies, considering the influx of superiorly skilled individuals from emerging and developing countries along with the presence of high-risk investment capital, the changes we can expect to see over the next 12 years can best be described by VUCA.

Now is the Time A new Digital Journey

So how are companies to handle this? As expressed in the famous quotation below (**Fig. 3**), we must adapt to change. In other words, we need to utilize digital technology in business, and transform the corporate culture, climate, and the way organizations operate to facilitate effectiveness in the digital age. The popular nomenclature for this is "Digital Transformation" (DX). Since this process is rooted in IT, CIOs and information systems departments are responsible for leading the way in DX.

This sort of transformation requires following a sort of path that we call the "Digital Journey." Unlike a trip or traveling, a journey implies transitioning from one state

to another over time. Therefore, this is no simple path. For this journey, no clear map exists, unexpected events and various challenges are sure to arise, and there will be a long process of trial and error.

Sticking to existing models and maintaining the same means of operation will not suffice. In order to avoid being left behind as the world changes, all any company can do is set a course for a digital journey. However, it is not necessary to tackle this stringent alone. By having a partner familiar with digital technologies, a company increases its probability of success. This collection of articles and discussions is meant to act as a guidebook for companies with sights on just such a successful digital journey.



*It is not the strongest of the species that survives,
nor the most intelligent that survives.
It is the one that is most adaptable to change.*

Note: These words have their basis in the famous English naturalist Charles Darwin's renowned work On the Origin of Species. However what Darwin actually said was "Those who survive are the ones who most accurately perceive their environment and successfully adapt to it" with the phrases "strongest" and "most intelligent" added later by an American economist.

Fig.3: How does a company deal with being in a turbulent era?

VUCA

This acronym was coined using the initial letters of Volatility, Uncertainty, Complexity, and Ambiguity. It is meant to express circumstances where it is difficult to predict the future of societal and economic environments. It is often used in the context of "We live in a VUCA World."

"Becoming Journey Partners" Fujitsu's Knowledge and Readiness

Tatsuhiko Shibasaki SVP, Head of Digital Transformation Business Unit

Takeshi Miyagawa Head of Strategy Planning & Research Division, Service Business Management Unit

In a VUCA World, it is hard to predict 3 years ahead, let alone 5 years. The "era of sustained competitive advantage" using cost, leadership, and focus strategies, advocated by American economists such as Michael Porter, has come to an end, and an "era of temporary competitive advantage" (American Professor Rita McGrath of Columbia Business School) has arrived.

Overall awareness of business-related matters is on the rise. According to a survey by the Japan Electronics and Information Technology Industries Association (JEITA), companies that think "IT investment is extremely important" has increased 1.6 times from 2013 to 2017. Changes in perspective towards "offensive IT investment" are definitely occurring (Fig. 1).

In response to the situation faced by many companies, what can Fujitsu do? Or, what should be done? It is clear that the answer goes beyond conventional SI, in other words beyond information systems development, IT equipment / software development, and sales. Of course,

need for these will continue to exist. In order to adapt these are still essential businesses, and IT vendors also have the responsibility of evolving the group of business systems known as Systems of Record.

However, these differ from what companies existing in a VUCA World are looking for. Above all, these alone will not do much to justify the value of Fujitsu's involvement. In order to continue to be a reliable and necessary entity for companies, what kind of digital journey must Fujitsu itself go on?

While pondering these sorts of thoughts in 2015, we developed the idea of "Knowledge Integration" based on OODA loops and design thinking, and in 2016, we brought it to life by creating the "Service Framework for Co-creation." The framework also is a declaration of our desire to partner with companies as they go on their journey of digital transformation. Now, let us explain the backbone supporting it.

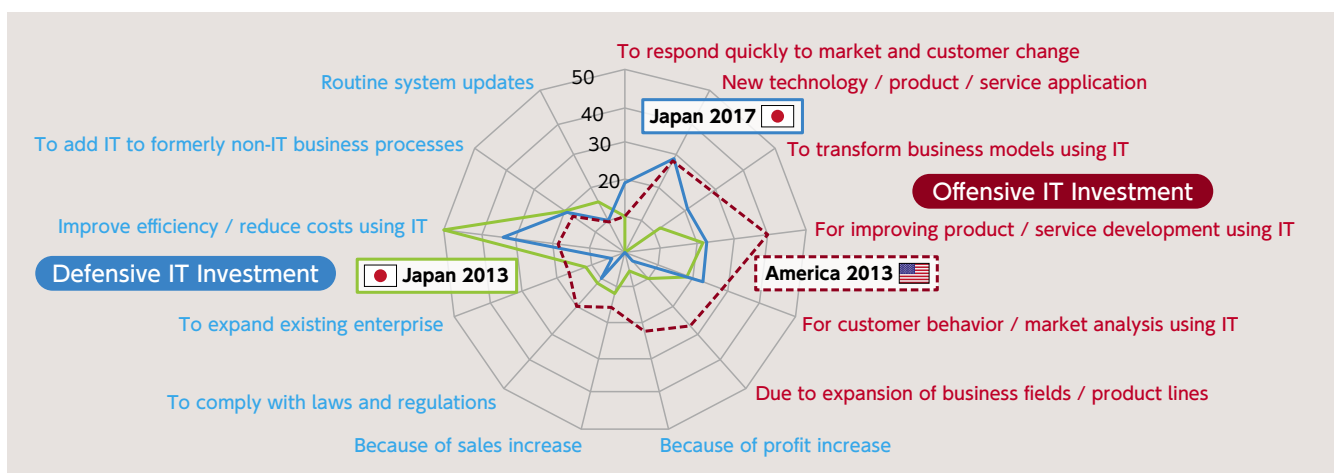


Fig.1: Causes & Applications of IT Budget increase (Source: Japan Electronics and Information Technology Industries Association)

Knowledge Integration Based on OODA & Design Thinking

In order to respond effectively to changes, we need to be able to have thorough understanding of the latest information as close to as in real time as possible. Some examples would include information about politics and legal systems around the world, major corporate actions taken in response to economic factors, how digital technology is being utilized, and the invention of new digital technology. In addition to being sensitive to news, it is also natural that we proactively gather information.

Furthermore, a company must consider its tangible and intangible assets, strengths and weaknesses, the circumstances surrounding employees and partners, and the circumstances and needs of customers; while accounting for that information, the company must then think of its options and the direction it should go in. Once a decision is made, action must be taken quickly. This process is achieved using the "OODA Loop": first, "observe" the situation; then, "orient" to address it; next, "decide" what to do; last, "act."

In recent years, design thinking has also garnered attention, and in fact, takes similar steps. For difficult to define and resolve issues, users of the method are first to

observe, then "think outside the box" (consider the issue freely and openly), form a substantive hypothesis, test the hypothesis, and then repeat these steps again. The OODA loop as a PDCA cycle where there are clear steps to be taken is relatively easy to understand in contrast to design thinking, which acts an analytical approach to dealing with defining and addressing a problem. In circumstances where it is difficult to predict what will happen, trial and error based on these processes and approaches to thought is necessary.

However, this is easier said than done. Digital technology is evolving at such a rate that it cannot be analyzed using conventional concepts, and it is difficult to gather information. We need services and systems that allow for the ability to understand various technologies and incorporate them into business and operations, as well as advanced technologies that allow us to develop these systems and services. This is also true of design thinking. Though it may be tempting to think it can be practiced with a great deal of information from books and the like, simply imitating a format often does not work well either, and headway is difficult to make without an appropriate coach or partner.

Based on these considerations, the concept of "Knowledge Integration" was formed (Fig. 2). Intended specifically

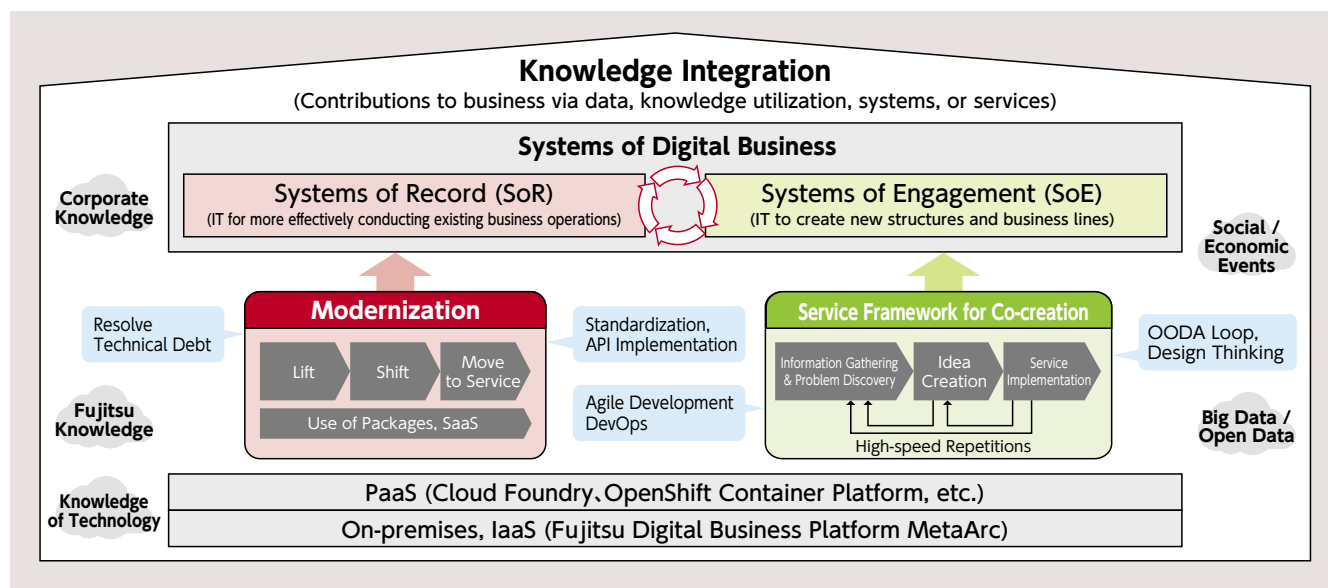


Fig.2: Overall Perspective of Knowledge Integration

for the "gathering of varied wisdom," it can be accurately described as "bringing together the organizational and tacit knowledge, explicit knowledge, individual knowledge, etc. of companies and Fujitsu, while also integrating knowledge of information and technology in Japan and around the world. The objective is to use this assembled information as a driving force for realizing business and corporate innovation."

Turning the "Gathering of Knowledge" into the Service Framework for Co-creation

That explains the concept of Knowledge Integration, but it needs to be developed into a method that can be put into action. In 2016, Knowledge Integration in Action was announced as a part of the Service Framework for Co-creation.

This will be discussed in greater detail in Part 2, but as an example, in the information gathering and problem discovery phase, we conduct on-site inspections both in and out of country and gather expert opinions. Experience with unique initiatives and technology from overseas in particular yields a significant impact in terms of raising consciousness about change and increasing motivation. Then, based on the information gathered (knowledge), we meet and form a hypothesis (idea creation), and leverage that for business purposes (implementation of services). The commonalities with the OODA loop and design thinking are recognizable.

Here we would like to once again address three things that we think are really important to understand. First, the Service Framework for Co-creation is different from simple goods and services. Acting as a partner

to a company, Fujitsu also takes on a great level of responsibility, and this system is our way of confronting our own digital transformation. For instance, Fujitsu recognizes that furthering our system based on the OODA loop, preparing the organization structure, improving human resources, and strengthening the IT environment through elements such as MetaArc, are all important responsibilities that we are party to.

Second, Knowledge Integration and the Service Framework for Co-creation are often thought of as "IT that creates new structures and business lines, or in short, promotes SoE"; this is not the case. SoR and SoE can be thought of as the front and rear wheels of a motorcycle. They are inseparable. Fujitsu's strength is to be used to carry both SoE and SoR forward, and moreover, we have a duty to do so.

Third, we want to address the question "Hasn't Fujitsu always dealt in SoE?" With regards to that, our company was not founded based on SI and entrusted development. Beginning with the development and manufacture of communication equipment in the 1960s, we developed domestically produced computers, while receiving criticism for taking too big of risks and being reckless. In the 1980s, we began our current SI and outsourcing operations, along with handling computer electronics such as PCs and mobile devices. A long history of adapting and taking on new challenges is ingrained in our DNA.

Fujitsu makes use of the concept of Knowledge Integration to act as a true partner in guiding companies to success on their digital journeys, working to accelerate the value we offer and our partners receive.

The Next Step on the Journey of Transformation Accelerating Digital Business on the Wheels of SoR / SoE

Last year, Fujitsu announced it would be setting out on the digital journey with customer and partner companies. So how did they face this rocky path that offers no shortcuts and how are they moving forward? I talked to two people who were central in leading the way.

Heading to Digitalization, Japanese companies set their sights

— Digital technology has begun to exert an unprecedented impact on business and society, and setting sights on the future has become a common proposal for companies. How do you see things actually progressing?

Imada: Between last year and this year there has been a notable increase, mainly among larger enterprises, in appointing people to a newly formed Chief Digital Officer position. While appointing a new kind of director is no simple matter, they have not really reached past this shared action, and there remains a need to make bold changes. I think there is an awareness of that. Reflecting on the situation, if you realize someone can setup and steal the market, then there is a sense of danger, and companies with that increased tension have begun to

move in earnest to face an era of fiercer competition.

In addition to CDOs, there are sections within companies being put in place explicitly to take on new challenges, which are recruiting enthusiastic personnel. Various efforts like this are spreading that are setup to be stimulated by these changes and nurtured within their companies. This is reflected in the example of Mitsubishi UFJ Financial Group, which has established a new company focused on the field of Fintech, Japan Digital Design. Cases have also appeared where collaboration extends beyond the boundaries of single existing companies and industries, such as LANDLOG, which was established by Komatsu along with NTT DoCoMo, SAP Japan, and OPTiM.

However, in contrast, there are not many active personnel specializing in the digital field. Digitally-talented personnel are not common in most normal companies, and at present, there is no easy way to recruit them.

Shindo: When speaking with clients, the difficulty of acquiring digitally-talented personnel comes up frequently. In many cases, while there is a kind of impatience about needing to make changes, there remains a substantial barrier when it comes to discussing the specifics of a company taking on risks and challenges. Starting with an awareness of the matters at hand to better understand what is going on in the world, we are able to foster ideas, but we are now faced with the problem of not having the people who can put things into motion when we reach the phase where we need to give these plans a shape.



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Corporate Executive Officer, SVP
Vice Head of Digital Transformation Business Group

Photograph: Hiromichi Matono

Tetsuya Shindo
Corporate Executive Officer, SVP
Head of IT Management Service Business Unit



Fujitsu put forth the concept of Knowledge Integration in 2015, which is built on the OODA loop and design thinking, and in 2016, we announced the means to put it into action with the Service Framework for Co-creation. In addition, there has been a considerable increase in consulting where we are asked "Can you provide people with practical experience to help 'give our ideas shape'?"

As a partner to our clients, we have focused our efforts on putting systems together that can help facilitate hopes related to achieving digital transformation. We see that what is needed of our company has roots that run deep, and we feel a serious responsibility to address that.

Training 200 Full-time Personnel Further strengthening ourselves in 2018

— Please elaborate on what you did to improve your system over the past year.

Imada: Last year, we established an in-house organization called the Digital Front Business Group. You can think of it as an artificial island, which we have built in order to put together a co-creation work style that differs from conventional approaches. Following that, we gathered 200 exceptionally talented people, and we have worked to nurture them to become what are called "digital innovators." Within this group of personnel, "producers" are responsible for co-creating with clients, "developers" explore the realms of technology, and "designers" conceive of business platforms.

While some of these people are already engaged in actual projects, in general once this training period is complete, they will at last enter a stage of working with clients to practically approach digital transformation. The backgrounds of these 200 people vary, including SE, middleware engineering, researching shared

technologies, trade, and so on.

In 2018, we have plans to further increase the number of people involved, and also train company engineers to be SEs. Naturally, it is not enough to just increase the number of people we are training, but we must also continue to improve the quality of the training and thereby the personnel. It can be a bit frustrating when classroom lectures and workshops are not enough to get the job done. Still, there is no substitute for daily "practice," so we have to provide a place for that, where each person can learn by being the lifeblood of an organization. They have to learn to think on their feet, and be hungry to do whatever they can.

Shindo: We are at a stage in transforming where experiences are being accumulated one at a time, and we need to be thinking about what worked well, what did not go as planned, and so on. Although there are some struggles along the way, we think it is a valuable asset to be able to say "we can stretch and move our minds and limbs," and we believe this will become our strength.

Working with Customers and Partners Co-creation as a phase of change

— You mentioned "co-creation" earlier. Could you be more specific?

Imada: Though obviously they cannot be discussed in detail due to our contracts with clients, we do have various projects in motion. For example, chatbots

for call centers. Contact centers are very important for companies in building healthy and sustainable relationships with their customers, but many companies often have a lack staff for these positions, and the centers add to the operational load.

Listening to this very real problem faced by our clients, we tried to think how our knowledge of technology could be applied to this issue. Going back and forth in discussion, we came to recognize how a chatbot might be applied. Information gathering and problem discovery, idea creation, implementation of services... We moved forward on the project using the Service Framework for Co-creation, and completed a mechanism that would play a part in advanced customer care response. We made it together with a digital innovator and middleware team, as well as with our clients. What we learned led to the fruitful solution "Customer Engagement Solution CHORDSHIP powered by Zinrai."

In talks with clients, we discussed how integration of component technologies like AI, the ability to hear a voice, and the chartable results of the system and services were not the only things that were important. Business on site is more complicated than one would imagine, and since there is no point of reference for new initiatives, things like identifying necessary functions and sustainable methods of operation are not commonly ingrained. Working together to exhaust as many lines of thinking as we can, we learn a lot, including adverse effects. That is precisely where knowledge comes from.

Shindo: Just one of these exchanges yields so much, and they play a major role in going on a journey where the destination is so hard to foresee. What we understand intellectually weighs differently than what is known by way of actual experience. The sense of how to do deal with difficulties when confronted with them, and the unique and different ways of application come out. That is why, as a company, we gain experience within a set framework, and strive to enrich our knowledge. Although this requires steady effort, what we accumulate becomes our strength, and it will lead us to results that live up to hopes and expectations.

Working Out Contract Formats Collaborating with clients

— When it comes to creating new businesses and services with clients, it seems necessary to contrive methods and work together in ways that don't really have a name yet.

Shindo: That's exactly right. Unlike developing systems based on requirements, it is necessary to think about, for example, how to distribute returns based on investments, and how should intellectual property rights be handled. Although this does not work well extending off of a traditional contract, we determine just what the minimum is we have to decide on, and first we consider the format that will enable us to move to commercialization as quickly as possible. We now have methods that allow us to make advancements more dynamically than ever before, and that gives co-creation its gutsiness. We're not just sitting around a table talking up theory; we're finding common ground where we can try things out. Of course, this also becomes knowledge for us.

Imada: We are making attempts with forming alliances with individual companies and collaborating with multiple companies. In digital business, it is necessary to share risks together and develop as a single unit. Since we know that traditional contracts and quasi-mandate agreements do not allow us to proceed as we would like, at this stage, we are working on various forms of role sharing and contract patterns.

Contrarily, an old theme is also re-emerging. Along with the new systems and services known as Systems of Engagement, it is also necessary for us to transform our existing Systems of Record. If both of these are not synchronized, then we will not be able to achieve change, and sustainable growth will not be possible.

Our clients have also noticed this, and recognition of the importance of speed is particularly widespread. We have received comments such as "we would like to try agile development methods in the SoR area" and "we want to apply techniques and methodology using cloud technology to modernize our SoR."

The Next Step of the Journey Systems of Digital Business

— So SoE and SoR need to evolve in balance?

Imada: That's correct. I mentioned earlier that this year we will be increasing our number of digital innovators, but we intend to mix about half that personnel proficient in SoR into each industry specialization of our System Engineers. They learn the technology and methods of SoE from experience, and they will also be able to use all their knowledge of SoR while shifting to digital. We are eager to put this system in place.

Shindo: As a part of that, Pivotal Japan's agile development service "Pivotal Labs" is being employed as Fujitsu's system engineer training program. Trainees will gain a thorough understanding of the methodology we need to use with lean startups and extreme programming (XP) as a base. In August of this year, we also have plans to establish Fujitsu Solution Square as another base for practical training.

— Does that mean that the Digital Front Business Group will be driving digitalization in the field of SoR?

Imada: No, projects related to digitalization of SoR will be led by SE leaders in each industry. Moreover, as the world's entire shift over to digital becomes more distinct, it probably won't make sense to clearly distinguish between SoR and SoE or decide that solely the Digital Front Business Group will be responsible for the matters entwined with digital transformation.

This year the SEs of industry-leading business groups participated in studying know-how at Fujitsu Agile Labs, and in returning to their original workplaces to lead SoR digital projects and the like, through active personnel exchanges, developed personnel able to act using both SoE and SoR.

In any given case, we seek to move past the barriers that restrict SoR and SoE, and accumulate various levels of experience to accelerate the digital transformation of our client companies via "Systems of Digital Business." I believe that the role of leading the way belongs to

Digital Front Business Group.

Leading in Digitalizing Customer Relationships Amassing achievements

Shindo: Of course, we want to be able to help our clients with whatever their ambitions might be, but if we focus on the context of what we have done up to this point and market conditions in 2018, the areas that would no doubt come up are "digitalization of industries and business," "digitalization of customer relationships," and "digitalization of socioeconomics." Of those, I think that digitalization of customer relationships and digitalization of organizations and work style will become dominant themes.

When it comes to digitalization of customer relationships, the approach doesn't follow the traditional one-sided variety where companies are just selling things to their customers; instead, we look at how to deepen ties between companies and their customers. In other words, we need to focus our knowledge on how to create an enriching experience. On top of expanding those endeavors, we are working on servitization using the Internet of Things, big data, and Artificial Intelligence; for the manufacturing industry, we have a business model that focuses not on sales of products but on providing products as services.

Imada: We have expressed our desire to be a partner to others in their Digital Journey. It has a nice ring to it, but this is meaningless if we cannot see where to go from the beginning and only end up copying the route that others have taken. There may come times where we are forced to backtrack, and while it is hard, being honest about this in these situations is important.

That is why we will never be caught standing still. In order to be a reliable partner to our clients, all the more, we have resolved to polish up digital technology and take on risks ourselves.

interviewer: Junji Kawakami, IT Leaders Editorial Department, Impress Corporation



C O N T E N T S

13	2-1 [Overview] Deepening & Expanding the "Service Framework for Co-creation"
16	2-2 [Gathering of Information] Europe and America, China, Asia, Israel... Directly Experience the Movements of Our World
21	2-3 [Idea Creation] Opening Doors with Learning and Practical Training 5 Points to Practicing Idea Creation
26	2-4 [Lean Startup] Organization, Contracts, and Personnel Needed for Agile Development
31	[Column] Sample Case of the Service Framework for Co-creation and Measures for Making PoC Successful

PART 2

Evolving the "Service Framework for Co-creation"

The "Service Framework for Co-creation" was built with the OODA Loop as its backbone, while also incorporating Design Thinking methods. It is intended to serve as a guide on the digital journey.

The system has evolved from the OODA loop into a framework for

- ① Gathering of Information, ② Idea Creation, and ③ Lean Startup and is expected to grow.

Deepening & Expanding the "Service Framework for Co-creation"

Minoru Sakai Senior Director, Digital Transformation Business Unit, Social Business Group
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Amid this wave of massive change that includes digitalization, each company must now tackle its own digital transformation. This digital journey must be embarked upon knowing the challenges that may lay ahead.

On the subject of this potential problem consciousness, the last edition of our mook published in May of last year (https://www.fujitsu.com/jp/documents/services/knowledge-integration/knowledge_integration_2017summer.pdf) discussed the "Service Framework for Co-creation" as a compass for navigating these waters (**Fig. 1**). This framework shows our preparedness to join other companies on this journey as a company partner, acting as both coach and player when it comes to digital technology.

In the year since then, Fujitsu has engaged in actual co-creation projects utilizing the Service Framework for Co-creation, expanded our "co-creation spaces" to invigorate discussion focused on innovation, and worked to further the training of our specialized "digital innovator" personnel.

Examples of Co-creation Projects in Action

Let us take a look at a solid example of "Idea Creation" in the Service Framework for Co-creation. We implement a design thinking program geared toward service creation utilizing digital technology, which works to discover and test possibilities through prototyping.

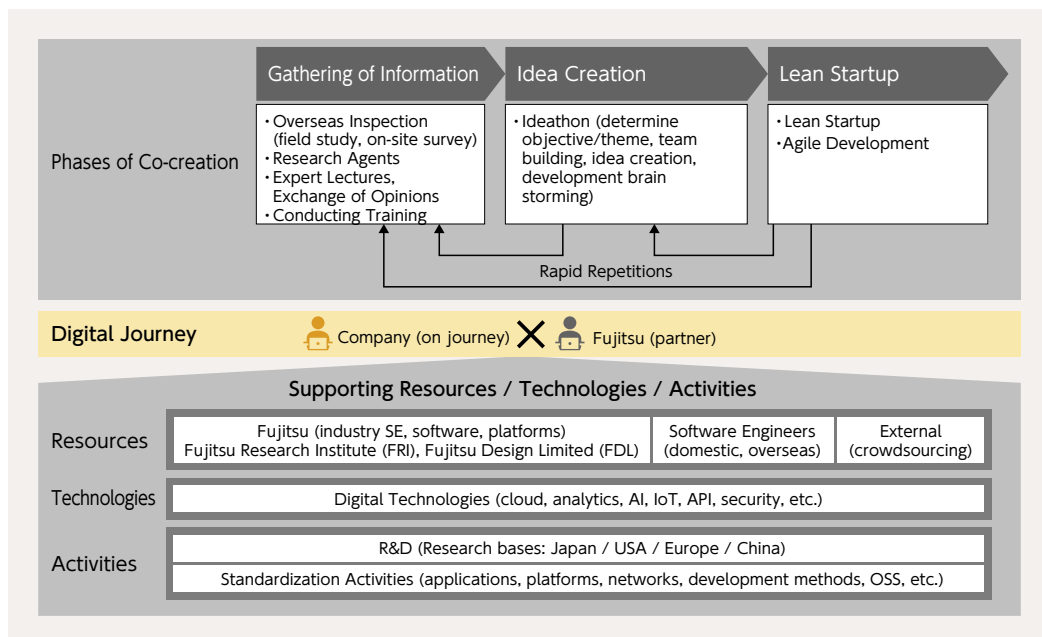


Fig. 1: Service Framework for Co-creation

One such instance is involved working with "Pharmaceutical Company A" on a project for creating new products. Company A had the idea of installing IoT sensors in existing products to create new products (services), and they were looking for a partner to realize that idea.

From there, Company A and Fujitsu began by developing this vision. Using our system based on the design thinking method, we defined the target persona (image of the target audience), thinking about what problems the persona has to deal with and how to solve them; this allowed us to discover ways to effectively refine the form the goods and services should take. Based on that information, we quickly developed a prototype. At present, we are conducting user tests and continuing to make improvements to the goods and services, and we are at a stage where we are refining them up for commercial release.

Another example is a town planning project involving "Railway Company B". Company B is actively engaged in using data on preferences to make it enjoyable for tourists and residents living along the railway line to enjoy traveling in the area. By conducting a smart stamp rally in 2017, we were able to implement a Proof of Concept project that verified the utility of traveler data. In order to proceed to the next step of developing the application, we began working from creating a concept for a service that users, as well as event planners, would want to use.

The discussion involved more than just Company B and Fujitsu. We conducted interviews and on-site surveys, including with extreme users (users who exceed average use), and after repeated discussions with various participants and use of worksheets, we put together a vision in-line with Company B's capabilities. From this ideation, we also created a screen prototype, used repeated user tests to make program corrections (lean), and carefully examined specifications. This sort of program using the "locations" of a company, such as those along the railway lines, integrated with our company's ICT, is something neither company felt they had seen elsewhere.

Although these are only two cases, the amount of projects we are engaged in grows by the day, including instances of B2B and AI application.

Establishing Co-creation Spaces

"Spaces" are also key to engaging in co-creation. The most common, which you are doubtlessly familiar with, is conference rooms that are typically intended as a place to meet and discuss for 1-2 hours. They would not likely be called a suitable place for discussing innovative ideas that fall outside usual business, making and leaving notes, or making simple mock-ups.

To address this, Fujitsu puts together spaces where those involved with a project can gather to have free and open exchanges, and events like idea creation workshops can be held. One such space opened in May 2016 in the Kamata district of Ota Ward Tokyo, and is called "FUJITSU Knowledge Integration Base PLY". PLY is outfitted with equipment for performing simple design work, such as laser cutters and 3D printers, and in the 2 years since its opening, around 30,000 people have used these facilities.

In March 2018, a PLY space was opened in the Shiromi district of Chuo Ward, Osaka, and this along with the bases operated by Group companies makes for a total of 8 bases (Fig. 2). The scale of each of these facilities are not all as big as PLY in Tokyo, and not all of them are equipped with the full array of 3D printers and the like. However, our know-how on how to deepen essential discussions is growing day by day. It is also worth noting that aside from these facilities, we also have our HAB-YU site in Roppongi, Tokyo, which is focused on dedicated discussion, and there is also our TechShop, which is equipped for full-scale fabrication and prototyping.

Training Specialized Personnel to Aid in Co-creation

In Japan Fujitsu and its group companies employ 27,000 engineers. Even though all of them are familiar with

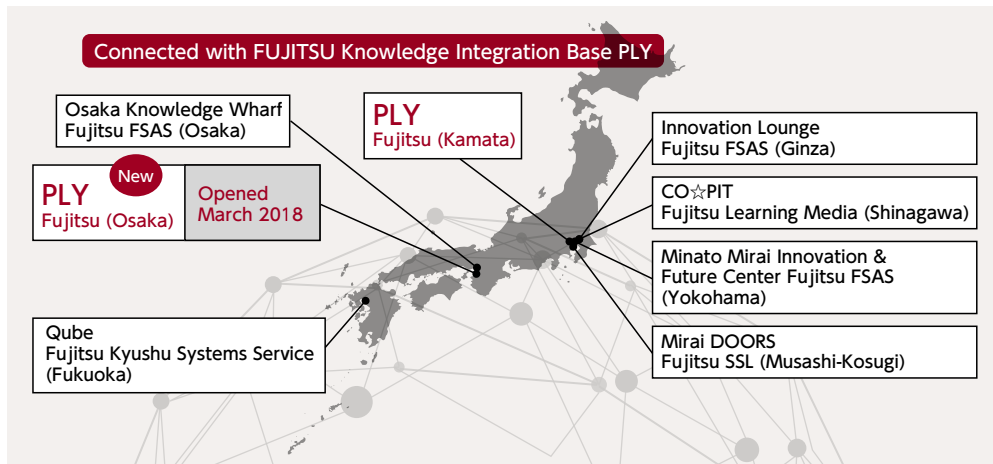


Fig. 2: Fujitsu presently has 8 locations with "spaces for co-creation"

digital technology, they are not all familiar with the co-creation work style. Therefore, in 2017, we selected 200 mid-level engineers, and gathered them together to form the Digital Front Business Group (DFBG), a department focused on advancing co-creation.

These personnel receive a 6-month education and training program to learn to effectively utilize the Service Framework for Co-creation. We call the program the "Digital Boot Camp." For the first 1.5 months of group training they are thoroughly devoted to learning about trends in digital technology and design thinking. In addition to lectures given by engineers and members of enterprises from outside the company who are engaged in working on new businesses in Fujitsu Group, as well as IT industry analysts and others, 40% of time is dedicated to practical exercise. During the period the trainees engage in ideathons and carrying out PoC based on what comes out of it.

In the 4.5 months after completing group training, trainees engage in on the job training by participating in projects and acquiring skills in our company's digital technology-related divisions. Not only that, but they are stationed at external venture companies, and by experiencing working side by side with employees, they learn firsthand the sense of speed required and what kind of work venture companies are engaging in. Additionally, in areas such as Kobe city in Hyogo Prefecture and Sabae city in Fukui Prefecture, we

receive requests from the municipalities and have our people working as staff members. These methods emphasize the objective of the Digital Boot Camp, which is to give trainees a sense of being able to act on their own, rather than engaging passively.

Of course, we do not think just implementing this boot camp is sufficient. In order to train skilled individuals who will act as partners on a digital journey, we also believe in rethinking personnel systems and assessment frameworks, as well as how we work.

Lastly, as a key topic related to the Service Framework for Co-creation, we should touch on agile development initiatives. This will be discussed in detail in 2-4, but for now, let us mention that Fujitsu has collaborated with the American company Pivotal, which is known worldwide for agile development, and we are training developers and designers, as well as engaging in establishing development environments.

Naturally, over time we have carried out many projects and gained experience. We take pride in sharing what we have learned with the world, but upon consideration, we also wondered if we were prone to overemphasizing quality. We are convinced that a major role required of Fujitsu is to incorporate the world's most advanced agile development, including building development environments.

Europe and America, China, Asia, Israel... Directly Experience the Movements of Our World

Junya Oizumi Research Project, Strategic Planning Department, Digital Transformation Business Unit
Satoshi Suzuki Fujitsu Reserch Institute, Senior Managing Consultant, Cross Industry Consulting Group

For companies, a digital journey has an unknown and uncertain travel itinerary. Additionally, the goals they set their sights on also change. While a goal may temporarily be put in place, there is always a possibility that another company will get one step ahead, and when that happens, the goal has to be changed. While on the journey, a greater goal may be discovered, and then a company may also alter its course.

This is why during the first stage of the journey, we work to gather information as wide as possible, and then need to constantly check our current position, as well as our heading. For example, we attend IT-centric conferences, consult expert opinions, in order to meet with other companies at home and abroad both inside and outside our industry, and so on. This first step in the OODA loop, "Observe," is crucial and absolutely worth the effort.

Based on this mindset, in the first phase of our walk together on the digital journey, using the service framework for co-creation, we engage in research activities for "Gathering of Information". In acting as a partner to support the research activities of companies or investigating and reporting independently, Fujitsu arranges ① investigative studies, ② contract/agreement research, ③ lectures by experts and specialists, ④ training, and similar related activities. The contents of our services in this regard are being updated daily. Here we will mostly focus on explaining areas such as advanced digital business and investigative research related to companies (Fig. 1).

The Value of Visiting Places Conducting Digital Business

A picture is worth a thousand words. In order to

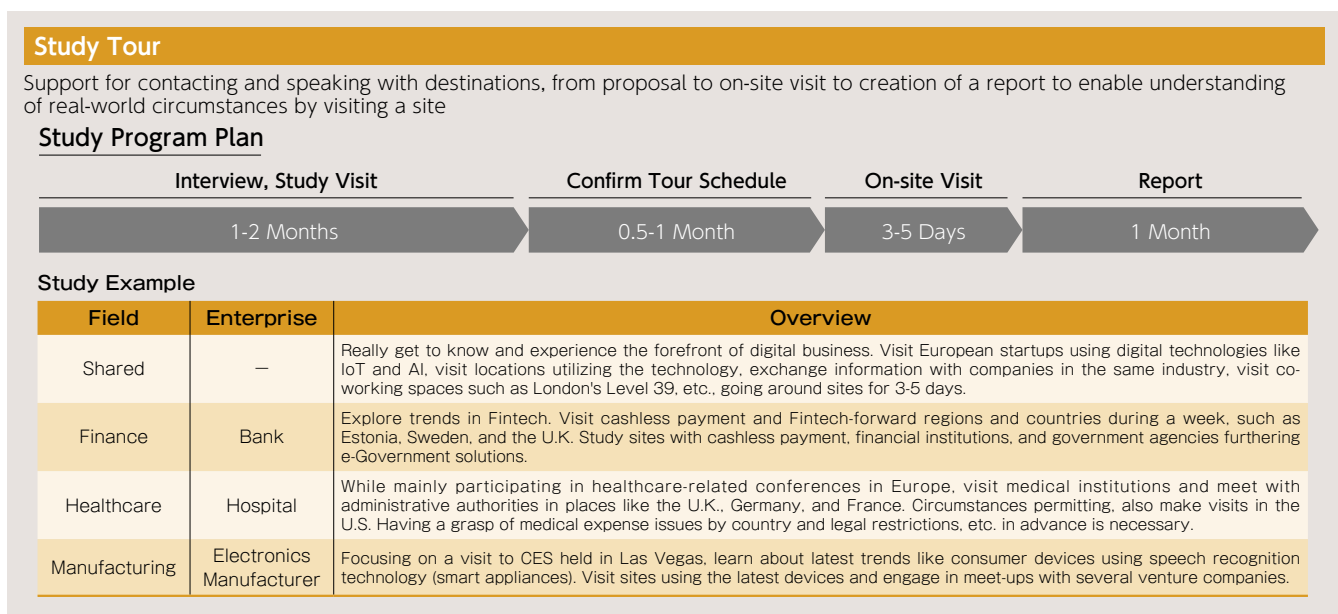


Fig. 1: Example Plan for a Study Tour

grasp and comprehend the current state of things, it is absolutely necessary to visit many areas engaging in advancing efforts overseas, as well as those working locally. We get to hear about and experience the kind of problem consciousness that exists on-site at advanced companies, in what ways they utilize digital technologies, what technologies and services they have implemented into regular use, and the structures and usage procedures that guide those actions. This takes time and money, but in the end, this is the most effective and quickest route.

However, it is not realistic to try and go everywhere in the world with no set plan. That is why Fujitsu takes into consideration the particular needs and circumstances of each partner company, while making full use of our internal and external networks to select destinations to visit. We make a list of company locations and research institutes that are valuable to consult with, and we create a schedule by making appointments for visits. On top of that, we go along on the visit, and engage in the research activities alongside the company.

Some examples of places we may go include financial institutions in Western countries, such as the Bank of America from the U.S., Barclays and RBS from the U.K., and ING Group from the Netherlands; major manufacturers like Siemens from Germany, ABB from Switzerland, and Philips from the Netherlands; and retailers like Walmart from the U.S., Tesco and

Ocado from the U.K., Metro from Germany, and so on. Although these are only a few examples, there will be companies conscious of the issues in each industry, and we visit those companies and exchange opinions.

Still, such visits are not always easy to arrange. There are many cases where a visit might be refused with the destination passing along a message to the effect of "why should we take the time to explain our digital business endeavors to Japanese companies?" However, Fujitsu has bases worldwide, and we have built relationships with various companies and organizations. We also have the ability to garner cooperation from our overseas partners, such as IT vendors.

By putting forth our best effort, the likelihood of getting appointments is relatively high. When the company is in the same industry, there is also a possibility that a give and take of information can be established. Leveraging a variety of means and studying companies making advancements overseas is of great significance in understanding the current situation and considering a company's future.

Getting a Grasp on Current Affairs at Conferences and Trade Fairs

Visits are not limited to going to individual companies. Rather, conferences and trade fairs where companies dealing in advanced digital technologies gather are more

Month	Name	Location	Overview
1	CES	Las Vegas / U.S.	World's largest event gathering startups to major companies
2	Mobile World Congress	Barcelona / Spain	World's largest mobile and networking-related event
3	SXSW	Austin / U.S.	All-inclusive coverage of services from music, images, and digital gadgets
4	Artificial Intelligence Conference	Beijing / China	AI-focused conference; in addition to Chinese companies, Microsoft, Google, etc. participate
4	Hannover Messe	Hannover / Germany	World's largest industrial trade fair; combined exhibition featuring multiple specialized exhibitions related to industrial technology
5	Global Blockchain Conference	Dubai / UAE	Conference on blockchain use in virtual currency, healthcare, government, finance, etc.
6	CEBIT	Hannover / Germany	World's largest computer and digital tech exhibition
7	RISE	Hong Kong	Asia's largest technology conference
8	Black Hat USA	Las Vegas / U.S.	Conference on cutting-edge cyber security
9	IFA	Berlin / Germany	World's largest consumer electronics and home appliance trade fair; brings together latest technology
10	Crowdsourcing Week Global Conference	Washington DC / U.S.	Conference focused on crowdsourcing
11	AI Expo North America	Santa Clara / U.S.	AI-focused exhibition; held in other regions, such as in Europe

Table 1: Conferences and trade fairs held around the world; this represents only a portion

common (Table 1). CES is held in the U.S. each January, and has become an expansive trade fair for digital technologies, including automatic driving technology. Mobile World Congress (Barcelona, Spain) held from February to March is indispensable in learning current trends in mobile and IoT technologies. There is also the largest Artificial Intelligence-related conference each December, the AI World Conference & Expo. Aside from these large conferences, there are specialized conferences held almost daily in Silicon Valley and Barcelona.

Of course, it is not always worth going to these events. In addition to language challenges and trouble comprehending some of the technology, due to their large scale, they can give the impression of "this is too overwhelming" or "struggling to understand what trajectory companies are taking". There is also a common trend of people just going around to the major booths of established names and overlooking the booths of startups. One place where startups can be found is "Eureka Park," which is a part of CES (Photo 1). This is a special area where startup companies gather, and while attention in recent years has increased, since it is far from the main venue, few Japanese companies currently visit.

However, this is not good practice for learning. That is why Fujitsu assigns research staff to participate in numerous exhibitions and trade fairs. Through preliminary surveys and lectures, they do their best to see as much as they possibly can. To be honest, not all exhibits can be covered, but even so, it still makes the most sense to receive support from these expert staff.

Although this is a little off subject, conferences and trade fairs are useful for more than just gathering information and studying. They are also great for developing prototypes of some products and services and exhibiting them. Since attendees come from all the different levels of various industries from a multitude of regions and countries, we can obtain good feedback and improve our awareness of current trends, and the events also provide chances to meet new people.



Photo 1: List of exhibitors at Eureka Park, which focuses on startup companies as a part of CES. Over 800 companies were presented in 2018. "Eureka" happens to mean something similar to "I found it!"

Recommended events for these activities would be the European Tech Open Air (Berlin, Germany) and South by Southwest (Austin, Texas) in the U.S. There is also a worthwhile event in Japan called Myojowaraku (Fukuoka).

Visit Silicon Valley Experience Innovation

There are many facilities and organizations that are worth a visit overseas. In Silicon Valley for example, there is a design thinking institute based in Stanford University called the "d.school"; a co-working space managed by Amazon called the "AWS Pop-up Loft"; a venture company incubation facility called the "Plug and Play Tech Center"; and the "b8ta store" for the specialized exhibition and sale of IoT technologies, to name a few (Photo 2).

In any case, there are standard spots to visit when taking in Silicon Valley, and to that extent, there is a lot of information, such as notes taken by people on prior visits. However, if you have never actually been, visiting these is highly recommended. Whoever the staff and whatever the facility, you can best experience how they work by visiting and seeing it for yourself. If you have an appointment and visit, you can speak with managers, and even if that is not the case, you can still speak to engineers, students, and others who are on site.

Naturally, you should do some investigating before you go. Let us consider the "b8ta store." While the location provides valuable opportunities to see and handle various IoT devices inside the store, with online sales having become the norm, how does a location like the b8ta store for the exhibiting and sale of these items run? If you look into this in advance and then go, you will develop a much deeper understanding of it (the answer is it uses a model where money is paid by exhibitors to have their products advertised there). As for Fujitsu, we provide this sort of information from the side. Although it is not in Silicon Valley, this January Amazon Go also opened in Seattle. It is a store that you will want to experience, even if your company is not in retail distribution.

These places of interest are not limited to the United States. In Shenzhen, China, now said to exceed Silicon Valley, IT companies such as Huawei Technologies, Tencent, BYD, ZTE, and DJI are headquartered. These are worth seeing simply for how their scale and facilities differ from the headquarters of Japanese companies. You should definitely visit Huaqiangbei at least once; it is said to be Asia's largest electronics market, featuring software parks and automated, unmanned convenience stores.

In what has been called the second Silicon Valley in Israel, every autumn a conference for startups called DLD (Digital Life Design) is held. It is good to visit these startup companies that helped get it off the ground. Over in Europe, in Amsterdam, they are advocating a "Sharing City"; Industry 4.0 has come out of each city in Germany; there is the core of finance in London, Belgium, and Luxembourg; and prominent e-Government endeavors are being undertaken in places like Estonia.

In the U.K., there is also a movement calling for partnership with Japan in the technology field called "Innovation is Great" (<https://www.innovationisgreat-jp.com/>). DeepMind, creators of "Alpha Go," was founded there, and their AI talent is putting a strong focus on uses in healthcare and robotics. Fujitsu also happens to have its greatest presence in the U.K. out of all of Europe.

The amount that can be learned just by visiting any



Photo 2: See and use various IoT devices at the "b8ta store"

area is limited. We need to study information on existing companies, venture companies, and research institutes, and then we work to get appointments for visits to have proper discussions. Fujitsu can provide support to our digital journey partners in this arena by making full use of the global network and personal connections we have built (Fig. 2).

Also Using Commissioned Studies and Training for Workers

Up to this point, we have mainly introduced what it is to visit and study at events and locations. However, there are limits as to the time and expenses that can be used for these activities. For that reason, we can provide "commissioned studies." Although this probably does not need to be explained, Fujitsu has researchers and engineers expertly studying IoT, AI, blockchains, and so on. These personnel will look into something like "trends of AI use in the healthcare field" and report back on it.

We have a program set up where lectures are given by experts to allow for the exchange of ideas with specialists from certain industries and academia. Personnel are assigned using experts registered with Fujitsu Laboratories and Fujitsu Research Institute, or people within the personal networks of those experts, to also engage in effective facilitation. Listening to opinions is effective for planning study tours, and this

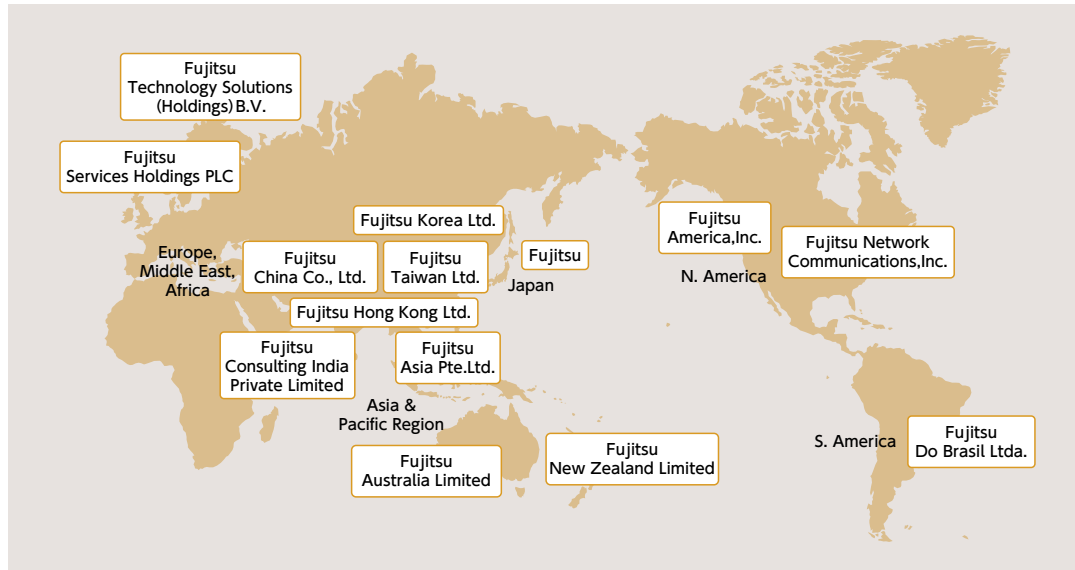


Fig. 2: Global bases support information Gathering of Information activities

also can be effective for diversifying perspectives to deepen knowledge of a specific theme after having visited somewhere.

One more source of training is the FUJITSU Digital Business College started in 2017 (Fig. 3). There is group training and includes a "digital strategies" course for departmental managers, as well as prepared courses on "design thinking," "AI & analytics," and "security"

for workers. Each of these courses is conducted with leading experts in each field acting as supervisors and speakers, and in 2018, two additional "digital strategies" courses will be implemented. Additionally, in the "digital strategies" course a Silicon Valley workshop was included that from 2018 onwards, we plan to offer as an option in the courses for workers, as well. Through this series of activities, Fujitsu works to put "Knowledge Integration" into real-world practice.

Commissioned Study

Experts research and report on the efforts of domestic and international digital businesses and latest trends in technology

- Specific subjects can be discovered through study tours/visits, and experts are called upon to help when deeper investigation is needed
- While connecting efforts of advanced companies to transitioning business models, experts research and make considerations
- Look into latest technological trends (IoT, big data, AI, security, etc.) and seek out promising trends

Lectures from Experts & Specialists

Diversify perspectives through exchanging opinions with experts and specialists with specific industries, businesses, and technologies as themes

Ex. Round table exploring the theme of using AI to improve points of customer contact (half day to a day)

- Expert lecture (trends in sophistication of contact with customers, etc.)
- AI experts present possibilities of using AI in contact with customers
- Exchange of opinions, closing (sharing on problem awareness and related subjects)

FUJITSU Digital Business College

Four kinds of training courses for training personnel to further and execute digital business at a company

- **Digital Strategies Course** Develop a mind and perspective for leading digital business
- **Design Thinking Course** Learn methods of using design thinking for business creation
- **AI-Analytics Course** Training personnel to use advanced technologies such as AI, machine learning, etc., and implement practical business models
- **Security Course** Understanding security trends, and acquiring system design and operational knowledge based on attack trends

Fig. 3: Various means for supporting Gathering of Information

Opening Doors with Learning and Practical Training

5 Points to Practicing Idea Creation

Akihiro Kuroki Fujitsu Reserch Institute, Chief Senior Consultant, Business Design Consulting Group
Hidehiro Takeda Digital Transformation Business Unit

Of the three stages that comprise the Service Framework for Co-creation, idea creation operates in something of a unique way. In information gathering and problem discovery, results are likely to come from the time and money put in. Since the goals of lean startup are also clear, there will be a correlation between effort and results. However, idea creation is different. Creating excellent ideas does not have a direct relationship with time and cost.

This is the real charm of idea creation, but it is also what makes it difficult. While it might seem like a logical approach just to gather people together and have them put out ideas, in many cases this results in only very basic, vague, or bizarre suggestions. No doubt some of you reading this article should have experiences where you held an ideathon internally but it turned out a bit different than expected, or you incorporated design thinking but had trouble pulling together results.

We have managed many spaces for idea creation both inside and outside our company. One of the ideas we have come upon is that understanding of and training on methods are key for idea creation. In business and in sports, or even in games, we need to learn the fundamentals and build on them with experience and practical training. Everything has its fundamentals or basics, as well as standard techniques. These need to be mastered through repetition.

Focus on Utility to Users First

The value of experience and training are equally true for coming up with idea creation. After observing others brainstorming as an example, we can conduct our

own session; at the level of discussion where everyone is just having a good time, it is difficult to obtain the desired results. Effective methodologies for idea creation include approaches such as the *a) KJ method (affinity diagrams), the *b) SCAMPER method, and *c) TRIZ. More recently, design thinking and ideathons have come to the stage. The method best suited to the objective should be chosen, and it needs to learn and to try repeatedly. Always having questions about what you are trying to achieve and how you are approaching it is also important to the mindset needed for creating ideas. At the very least, you cannot simply expect something to come out of just running ideathons.

There is often considerable effort in creating an idea, though sometimes it can be easy. For example, in design thinking the three elements you need to establish are ① the utility (value) for users, ② feasibility of business expansion (Profitability of investment), and ③ the technological feasibility. Of these, ② and ③ have become comparatively much less of a hurdle than they were in the past. Though they may seem difficult, there are many things that are now possible to make happen, and means for obtaining capital and investments relatively easily are also increasing. We have become able to focus our energy on ①.

Given an understanding of the premises discussed, how are we to hold the kinds of meetings and discussions that are worthwhile for formulating ideas? How do we go about refining ideas we already have? In this portion, we will focus on five key points.

*a) KJ: Abbreviation of "Jiro Kawakita", emeritus professor of Tokyo Institute of Technology)

*b) SCAMPER: Abbreviation of "Substitute + Combine + Adapt + Modify + Put-to-other-uses")

*c) TRIZ: Abbreviation of the Russian words "Teoriya Resheniya Izobretatelskikh Zadatch")

① Boil Down the Theme to be Addressed

Above all, prior to a meeting, preparing the objectives of the idea creation project and devising a set theme are crucial. The process of idea creation is one of repeated trial and error. These provide to participating members a sense of the importance of the project itself, and encourage them to want to actively engage with the process.

Although there is no predetermined way to establish a theme, a good way to devise the shape it should take is to consider the question "how can we achieve and implement our objective." This is also the starting point for ideas. The point here is to think about how you would express what it is in essence about what you want to create that gives it value and utility. To give an example, let us compare "how can we improve the functionality of the next generation of CRM systems?" and "how do we produce services that deepen our relationship to our customers?"

In the former, there is a high likelihood that the result will be working on improvements to existing IT systems. In the latter, there is a greater chance of broadening the realm of ideas to questions like "what kind of relationship do we want to begin with?" or "what sort of service should we have to respond to customer expectations?" At the same time, you can include descriptors that suggest wanting to make great leaps forward like "dramatically" or "10 times as efficient," as well as adjectives devising such members consider the project as their own issue by including "I" and "we."

② Team Building for Idea Creation

Communication among participating members, or team



Photo 1: The marshmallow challenge using marshmallows and pastas to build as high a tower as possible.

building, is also important. In an idea creation meeting, teams usually are made of 4 to 8 people. In order to enable lively discussion, if 20 people participate, they should still be split into 3 to 5 teams. Each team should have diverse members. By having members with different positions in the company, specialized skills, genders, ages, home countries, and concerns in their daily lives talk to one another as fellow group members, they can each come to understand perspectives they would not otherwise have access to.

We hope special attention is given to the fact that simply forming teams is not enough. To encourage members to engage in active discussion and formulate innovative ideas, fostering a mutual understanding among them is an essential starting point. There are cases where days can go into just developing this level of communication. So what exactly do we do to achieve it? A group dinner and/or drinks are of course okay. Personally, we recommend something with a game-like element to it, so that in a shared time and space team members can engage in a collaborative effort together.

Method	Overview
Persona	Consider a target audience, trying to think from others' perspectives; think based on age, gender, occupation, hobbies, place of residence, values, income, etc. what would make this person happy and what would not.
Idea Sketch	Members roughly sketch what ideas they find interesting using letters, symbols, onomatopoeia, etc., and shape it.
Customer Journey Map	From a user's perspective, illustrate the experience before during and after use. This is used when depicting an ideal experience, and when dropping into a specific UI.
Press Release	Assuming the idea came to fruition as a service, consider what will resonate with users and describe it.
Mockup	Create a trial version of the software UI, visually incorporate details that cannot be expressed in writing alone.
Elevator Pitch	This presentation method briefly summarizes the idea in the time it would take to ride an elevator. Include what is being offered to what user base, and how it differs from existing services.

Table 1: An outline of each method to be used according to objective and setting.



Fig. 1: Idea sketch example. Do not worry about artistic skill; just try and draw a basic sketch.

An example would be the "marshmallow challenge." This is a simple game using marshmallows, dry pasta, tape, and string to build a freestanding tower (Photo 1). Of course, the goal is to build a tall tower, but this can prove to be a greater challenge than one would expect, and the trial-and-error project will become a shared expert. This is only natural since it is unlikely since no one has tried doing this before. This sort of "everyone doing something together they have not done before" is effective in making it easier to see the individuality of each member.

One more thing we should consider is establishing rules and making them known to everyone. In order for everyone to be able to share their thoughts without being inhibited by age or position, it is best to decide rules in advance, and to tell everyone what they are. A few common sense examples include things like all opinions should be heard (everyone voices an opinion), members should take turns taking notes and writing memos, when someone gets up or leaves to get drinks, etc., he or she should let other members know, and so on. In summary, the two important points about team building are to develop "a mutual understanding between members" and "establish clear rules."

③ Repeated Divergence and Convergence of Ideas

So how do we proceed with the actual discussion? It

is difficult to shape an idea simply by showing what each person has come up with or talking. Therefore, a "divergence phase" is proposed to explore various possibilities, and then to work on emergent ideas and narrow them down, this is followed by a "convergence phase"; they are then repeated in this alternating fashion. It is also important to discuss the "exact shape" of the idea and also "abstract" its essence. These are the basics.

At this time, you should incorporate various idea creation methods (Table 1). One useful tool for divergence is an idea sketch (Fig. 1). This works for any user or problem, and it is using words, symbols, onomatopoeia, and so on to sketch out a sense of things. While artistic ability can be useful, as long as all the members can understand the images in the context of the conversation at the time, then the quality of the drawing is not an issue. More important is helping to visualize the idea and give it a clear, concrete shape.

What can be particularly difficult is finding a good point to take from a seemingly absurd idea. If you can do it though, this effectively nurtures an atmosphere that encourages people to think more outside the box.

Giving attention to off-the-wall ideas is something to keep in mind when converging. When narrowing

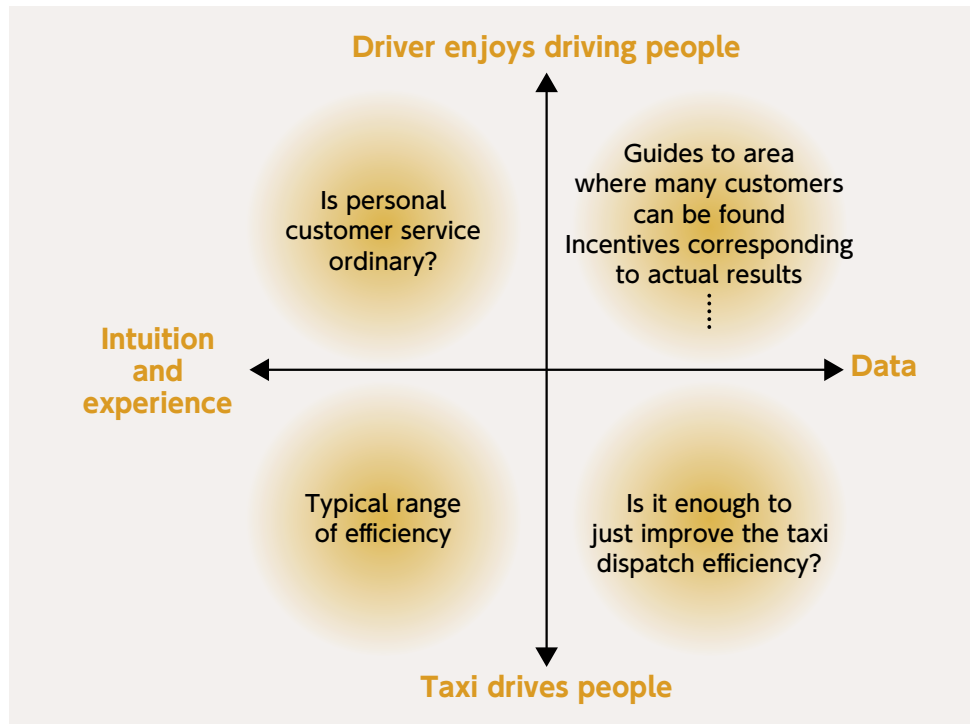


Fig. 2: Example of Diagramming Method to Expand Ideas

down a great number of ideas to only three, there is a tendency to choose things that seem easy or practical. Rather, intentionally seek out those things that give a slight sense of discomfort or seem a bit unusual. When too much emphasis is placed on practical use, often the only idea that will come out is one that makes a slight improvement on something that already exists.

④ Recognize Preconceptions and Biases, Reverse Them

After convergence, there are some things to take note of prior to developing and making things out of the ideas. Explain the reason why the idea was considered "good" or "interesting." For example: for an idea of using the Internet of Things to guide taxis to areas where passengers are often picked up, some reasons why it may have been considered a good idea could include "drivers do not have to rely on intuition and experience alone to find passengers" and "it could improve the motivation of drivers."

Looking at the idea this way, relating to the drivers there is a view that "intuition and experience" \Leftrightarrow "data" and from the standpoint of motivation, a view that "taxi drives people" \Leftrightarrow "driver enjoys driving people" that

we can see (Fig. 2). By crossing these axes, it becomes easier to identify where exactly our ideas are positioned and whether or not there are any other innovative ideas that might develop from any related quadrant.

Taking Figure 2's "using data can make driving more enjoyable" quadrant, we can think of other ideas like using data to make the ride more efficient or having a function to give incentives based on the number of trips and the travel distance. Using these methods, we can distance ourselves from beliefs and commonplace thinking that can inhibit innovation, and we can formulate ideas that do not fit into a standard frame. By organizing the types of views and aspects just discussed, we can get a better handle on what our preconceptions were.

⑤ Developing Ideas that Move Between Specific and Abstract

As an idea becomes solidified, it's time to verify its usefulness. Before developing services and systems in the lean startup phase, there is one more step, which is the process of incorporating the idea. There is no set way to do this, but let us take a look at two useful



Fig. 3: Example of a mockup. No need for it to actually move and work. Once a series of options for use is designed, show it to intended users and get feedback.

methods. One way is to write a "press release" for the time the fully-realized idea would be made public. Amazon.com practices this method, calling it "The Future Press Release" (<http://the-amazon-way.com/blog/amazon-future-press-release/>).

To write this press release, the elements essential to the project need to be filled in, such as a title and overview that briefly convey the features, text detailing its background and features, when it will become available, the price, and so on. Since this is a message concerning an as of yet vague project, naturally it is not actually released. Even if the detailed specifications end up being changed, we still have to consider the real worth and functionality of the to-be-realized idea in earnest.

Another approach is to create a mockup (**Fig. 3**). Specifically, a prototype of a model and trial UI design. You have to consider the fine details that are difficult to put into words, and depending on the mockup, you also have the advantage of considering the user experience. Since these are processes for actualizing ideas, after making a mockup, you abstract it once more. From mockups, you discover "how to express something's value in a single word."

One method of doing this is the so-called "elevator pitch". The idea is that you are on an elevator with a VIP and

only have a very short time to present your idea. What you are offering to what users and how your service differs from what already exists in the market needs to be quickly summarized. Going back and forth between specific and abstract will refine your idea.

Dealing with Hitting a Wall

While formulating ideas and making them into something solid is exciting and fun, it is also a challenge. You can often run into a wall. So what do you do then? Although there is no single answer for occasions when discussion does not suffice, thinking about a change of direction (pivot) can be beneficial. Naturally, rather than changing direction haphazardly, based on the users, target market, implementation tools, and other related items, you need to try changing up one of the project's elements.

This might not be expected, but it is important to return to your original purpose. When we run into a wall, if we can discuss "why are we working on this?" again, there are many cases where a new perspective can come into view, since the experience of working on idea creation is already there. In conclusion, idea creation is not a completely straightforward process. We all need to remember that it is important to repeat the process over and over to accumulate learning and practice.

Organization, Contracts, and Personnel Needed for Agile Development

Hidekazu Tanaka Designer, Social Economy Solution Office, Digital Transformation Business Unit
Kenichi Fukumura Digital Transformation Business Unit, Agile Business Development Department

Once you have assessed an idea as being worth trying out, it needs to be implemented as a service as soon as possible and released. There is no way for us to wait for services that incorporate all ideas and go through the traditional software development process that moves from concept to defining requirements, to design, to development, and then finally to testing before release. Even exceptional ideas can become obsolete after a few months. What is more important is to get feedback from people using the service, and then proceed to make continual improvements and adjust the fit and direction those services take.

Starting small and gradually adjusting the trajectory in this way is what is known as agile development. Agile development is not just for services either; it can also be used by lean startups to refine services while exploring customer needs (Fig. 1). Taking this a step further, the approach adopted by lean startups is "everything is a hypothesis, so we make prototypes and active services to work together with users utilizing them to examine

our hypotheses." If what is provided receives a negative reaction from users, that is to say the hypothesis does not hold and neither would the business itself, then we have learned one of the most important things we can from hypothesis (idea) implementation. We implement the most basic form of the service that users can utilize, and test our hypotheses while obtaining feedback.

Therefore, this kind of failure and reworking (trial and error) becomes central to the process. This is a major difference from traditional system development. Inevitably, the method and environment of the lean startup, the details of the development process, and the composition of the team working on implementation, etc. will also differ. Of these, the tools and environment for implementing services at a rapid pace will be covered in Part 3-8. Here we would like to focus on explaining organization, personnel, and forming a partnership contract, with regards to the indispensable approach for advancing a lean startup that is agile development.

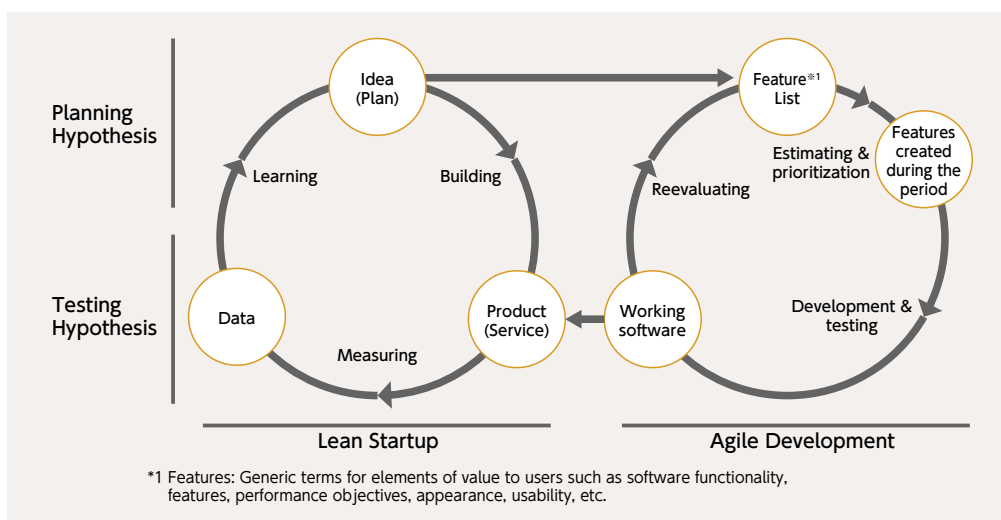


Fig. 1: Lean Startups and Agile Development

Partnering with Pivotal, Cutting-edge Agile Development in Japan

Before getting to the main topic, allow us to touch on our collaboration with the American company Pivotal Software. Prior to that time, Fujitsu had formulated an agile development model called "FJ-Agile." In 2013, we applied this approach to the contract support system of Tokio Marine & Nichido Life Insurance Co. Ltd. and the others, accumulating experience in the field of business system development. Of course, we had also applied agile development to external system development through things like the web, but the agile development was mostly for SoR (Systems of Record), and as a contrast we had little practice with agile development in SoE (Systems of Engagement).

So in early 2017, we started to discuss what we should do, and we decided to use "Pivotal Labs," whose members are renowned worldwide as professionals in agile development. In April 2018, we announced a policy to train agile staff, who could support the digital transformation of companies.

Although they are not as well known in Japan, Pivotal

has been specializing in the practices of lean startups and agile development for over 20 years. Pivotal Labs uses their methodologies, and is a general name for the facilities and services for providing the necessary mindset and work style. In America, Citi, General Electric, and Southwest Airlines; in Germany, Mercedes-Benz; and in Japan, Yahoo! and All Nippon Airways, among others, are all learning from that same company, and based on the acquired methodologies are engaging with agile development. Combining cloud-native tools and methodologies, they are providing the world's leading companies with support services for building software using agile development.

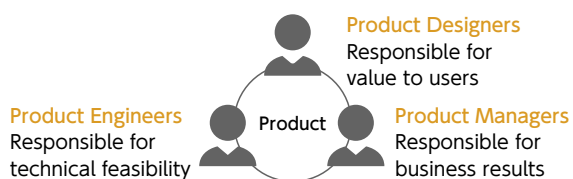
At the same time that Fujitsu is working on strengthening its agile development know-how, in order to further the service framework for co-creation, we have determined that Pivotal's world-leading style is indispensable to us, so we are incorporating it (**Fig. 2**). We have affiliated ourselves with Pivotal in order to train personnel and gain practical experience in agile development. We have already sent personnel to Pivotal Labs Tokyo, and they are receiving training in agile development. We have also partnered with CA Technologies in America. We make these trained personnel the core around which we array

① Thorough rules and principles of practice methods

Development	Design	Product Management
Extreme Programming <ul style="list-style-type: none"> • Short (1 Week) Iterations • Pair Programming • Test-driven Development • Successive Integration / Successive Delivery, etc. 	User-centered Design <ul style="list-style-type: none"> • User Interviews • Persona Formulation • Prototyping • User Tests, etc. 	Lean Startup <ul style="list-style-type: none"> • Identifying & Checking Hypotheses • Choosing Verifiable KPI • Validating Using the Minimum Utility Product • Judgements Based on Data, etc.

② Well-balanced Team

Pivotal defines 3 roles. Each role has a responsibility in terms of a business perspective, user perspective, and technological perspective, and are implemented to build a team to increase product value through collaboration.



③ Focus on Projects (Improving Value & Results)

<Work Style to Improve Concentration Ability>

- Members are residents at the Pivotal Labs Tokyo facilities (free from work other than the project)
- Concentrate on 8-hour days (no overtime)
- Work and on-site decision making divided into short time boxes
- High-context work style via extensive pair work
- Deliverables from whiteboards and tags (Resources that do not connect to product value are not produced), etc.

Fig. 2: Lean startup & agile development practices in Pivotal Labs (Created by Fujitsu using materials provided by Pivotal Japan)

our other personnel, so they can also learn. Ideally, this leads to a proliferation, and we train personnel who are familiar with agile development.

Establishing an Agile Development CoE at Fujitsu

Naturally, we are also concurrently progressing the developing environments, however lean startup will not work in the service framework for co-creation alone. In order to seek out as a shared fate, we need to define the roles of our organizations and personnel because it is necessary for us to set a contract to form a partnership.

Therefore, we initially established a facility which will enroot an agile organization and mindset, and also a CoE (Center of Excellence involving cross-organizational experts). Then we consolidated our personnel that has led and practiced agile development here, a place to practice the global-standard method together, and to support everything from idea creation to lean startup.

This is an effort to form a professional group to work as a partner with companies (clients) within the service framework for co-creation (Fig. 3). Of course, each personnel in the group are well skilled that can use necessary CI/CD tools naturally to receive feedback from users, plus companies are progressing to formulate that can concentrate on the value of products (services).

Neither quasi mandate nor simple contract work, new contract agreement has become important

It is also necessary to reevaluate how contracts are formed between companies and Fujitsu. Take for example a fairly common contract agreement that follows traditional norms. As is well known, companies establish the specifications for a contract in advance during the requirements definition phase (from User Interface[UI] to System Test[ST]), and in those cases, the vendor (Fujitsu) contracts for development pursuant to customer specification requirements at once. When it comes to requiring the exact exchange upfront with

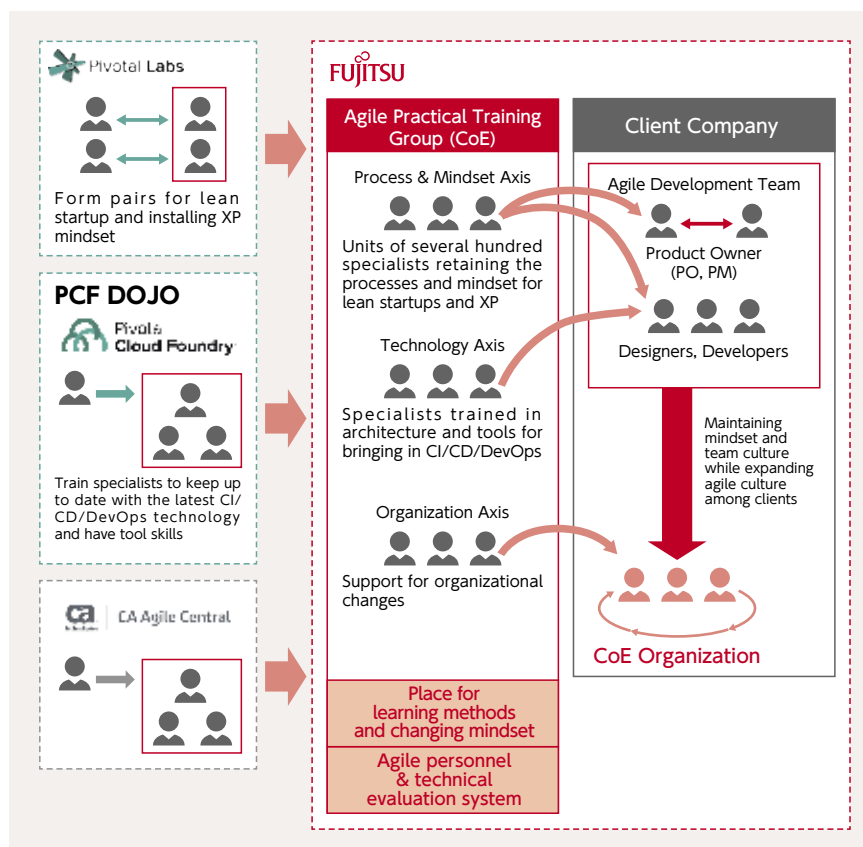


Fig. 3: System for practicing agile development; developing global standards for development methods at Fujitsu and partner companies

common contract, an agreement that works with agile development cannot be formed.

In terms of time and cost(cost of eligible skilled workers who carries out specific workload), a quasi-mandate agreement is another common contract that is a little more suited to agile development. However, the company (client) is then responsible for the completion of any systems and/or services. The vendor (seller's engineers) pays for "the quality attention of talented supervisors," and is obliged to carry out the commissioned work; however, if say the vendor's technical capabilities and efforts are insufficient, then the burden on the company increases. This aspect leads to difficulties in co-creation between companies and IT vendors like Fujitsu.

So what should we do? Since the circumstances pertaining to IT personnel, time, and investments that can be put into a project varies from company to

company, there does not seem to be any one-size-fits-all method for creating a contract. That is why, at Fujitsu, we use contracts that combine quasi-mandate agreements and contract agreements, and contracts that claim only the amount used for values like time and material (T&M); we are considering contracts that use revenue share to equally split the risks and benefits (Table 1).

The important thing is not to pass off risks, but to share in what those risks are by forming a unified team. In other words, this is not a relationship between a vendor and a buyer, but a relationship that builds an equal partnership where we pursue goals together.

Team Building to Focus on Value

Let us establish clearly how the team-building relationship between companies and Fujitsu should look. In the service framework for co-creation, there are the

Examples of Common Contracts Used with Agile Development

Contract Type	Overview	Benefits	Important Points
Quasi-mandate Agreement - Time & Material (T&M)	Capital, time, maximum cost, etc. decided in advance, and only the amount used by the vendor is paid for	<ul style="list-style-type: none"> Easy to foster a feeling of team unity Easy to focus on business value and user value Can quickly improve and alter hypotheses 	<ul style="list-style-type: none"> Since working together in the same place is important for results, a large burden is placed on client companies The ordering party (client) must bear responsibility for the completion of deliverables Difficult to determine whether there has been a violation of duty of due care/diligence
Quasi-mandate Agreement - Flat Rate	Contract for a fixed amount renewable in 1-3 month increments; reduces risk for both sides	<p>With T&M, in many cases the actual total work is less than the estimate, but while it is easy to control costs, it is also necessary to deal with management of actual versus forecast results for operations. When using a flat rate, since budget and duration can be fixed, internal adjustments for budget requests, etc. are easy. There are many cases where this is used properly for dealing with company budget management systems, ease of internal adjustments, etc.</p>	
Quasi-mandate & Contract Agreement Hybrid - Contract → Quasi-mandate	To investigate an initial hypothesis, a contract agreement is made to with the basic desired functionality, and later, a quasi-mandate agreement is switched to for the phase of trial-and-error repetitions.	<ul style="list-style-type: none"> The vendor bears responsibility for completion of deliverables during the initial phase Since the vendor's ability can be determined in the initial phase, changing to a quasi-mandate is comparatively easy 	<ul style="list-style-type: none"> Not suitable for cases where the specifications for the initial phase are vague If the necessary basic functionality is not determined carefully, excess, unnecessary functionality may be accidentally created
Quasi-mandate & Contract Agreement Hybrid - Quasi-mandate → Contract	The initial phase uses a quasi-mandate, and from the stage where it can be seen the necessary product/service has been made, a switch is made to a contract agreement for each iteration and each sub-function.	<ul style="list-style-type: none"> The vendor bears responsibility for completing deliverables within the scope of the contract Since this form of contract is close to traditional contracts, it is easy to obtain a consensus among internal stakeholders 	<ul style="list-style-type: none"> Since the speed of improving hypotheses and making changes is reduced under a more traditional contract, this is not suitable for cases where trial and error needs to be repeated many times; in case where it is difficult to divide periods and sub-functions into smaller units, there is a possibility of costs accumulating because the elements to be changed become significant Measures need to be devised that prevent contract procedures from becoming overly complex

Examples of Revenue-sharing Contracts that Share Risks and Returns

Contract Type	Overview	Benefits	Important Points
Usage-based Billing Model (SaaS, API, etc.)	The vendor builds the product parts at zero initial cost, and the client company will be charged according to the amount of usage, etc. during actual operation	<ul style="list-style-type: none"> Easy to focus on business value and user value Initial costs can be reduced (easy to start small) Relatively easy to determine the share, etc. for both companies 	<ul style="list-style-type: none"> In many cases the vendor side determines the changes to specifications, and companies' requests are not all necessarily included Software assets are often owned by vendors
Result Reward Model	Payment occurs based on a predetermined number of acquired users and earnings, and/or the rate of activation	<ul style="list-style-type: none"> Fosters a sense of team unity, and puts focus on business value and user value Can improve hypotheses and make changes quickly Possible to reduce initial investment (easy to start small) 	<ul style="list-style-type: none"> In many cases it is difficult to determine the roles and contributions of each company when it comes to things like how to calculate payment and distribution ratio in relation to sales or deciding intellectual property rights, etc. Companies disclose business figures to vendors (number of acquired users, earnings, activation rate, etc.), and also need to accept audits
Joint Venture Model	A company and a vendor create a joint venture and distribute earnings (share values) obtained from results	<ul style="list-style-type: none"> Equally sharing in the fate of the enterprise fosters team unity, and focus can be put on business value and user value Hypotheses can be improved, changes made quickly, and can lead to results on a short period of time Easy to take on new challenges that have not been tried before 	<ul style="list-style-type: none"> Plan design, both companies sharing responsibility, etc. is necessary in preparing to establish a joint venture company When moving forward while confirming the intent of each of the participating companies, sometimes the speed of decision making can slow down

Table 1: Beneficial and important points for different types of contracts when agile development is to be used

3 major steps of ① information gathering and problem discovery, ② idea creation, and ③ lean startup that need to be repetitively practiced. For all companies involved, one ideal is that on the Fujitsu side a team of the same personnel is formed, and they work on business transformation and creating new services.

However, there are many cases where this cannot be done. As an example of a simplified situation, when the hypothesis to be tackled has already been decided, the project may start from ③, lean startup. Another example would be a case where ① and ② are mainly being addressed by the business department, but ③ is being focused on by the IT department and digital transformation department. It is ideal for the people who formulated the exceptional ideas to be responsible for service development and provision, but such is not always possible.

Therefore, if we limit ourselves to lean startups and explain team operations, generally, we can unite our partner company's personnel and Fujitsu's personnel, and form a team of the product owner bearing responsibility for the business value, results, and policies; the designers who are specialists focused on improving the user value; and those who will fill the roles of developers from among tech professionals.

Among these roles, the product owner is particularly important. Even in past agile projects involving Fujitsu, the degree to which the product owner was integrated with the team could directly result in success or failure. On projects where things went relatively well, the product owner spent a lot of time with team members while considering the operation, and at the same time endeavored to communicate and make adjustments with stakeholders inside and outside the company.

The Product Owner is a Decisive Role

Naturally, Fujitsu also provides support, but in order for a project to be successful, it is essential for the product owner to think for itself. Therefore, the product owner from the company must participate. At the time of the

project, the product owner needs to shift focus from the work up to that point to the project at hand, and a major effort to change mindset will also be required.

To that end, it is also absolutely necessary to understand the organization to which the product owner belongs, and needs to be transferred authority to make prompt decisions. Fujitsu also provides the CoE, etc. for use for the product owner on the company side as a place to learn methods to promote projects as a lean startup and things like mindset shifting.

On the other hand, when it comes to designers and developers, they are not necessarily on the company side, and there is a good chance that this is not their first time working on such a project. Being proficient in the processes, mindsets, and tools in the SoE field of agile development is never a light burden. That is the reason why we think that Fujitsu bears responsibility for these areas. Of course, while working on a team, we support the training of designers and developers on the company side.

Despite this period of bewildering change in technology and the business environment, the business model based on the traditional relationship between the buyer (client) and contractor (vendor), where the personnel on the vendor side is largely responsible for system development, is still going strong. That is to say that there are many SoR that have no problems, and we are not trying to deny that. However, there are also undeniably aspects of this business model that have hindered the incorporation of SoE.

Returning to the main subject, a partnership in which the company in question and Fujitsu work together as a single unit is indispensable in embarking on a digital journey. This is not a relationship of "codependence" or one side leaning on the other, but a tight relationship based on mutual respect and trust. That is why it is desirable for there to be designers and developers on the company side that have certain skills.

Example of System Framework for Co-creation in Practice Efforts for Business Transformation with a European Oil Company

Kenji Uchida Manager, Frontier Computing Center, Technical Computing Solutions Unit

"What can we do with AI? For instance, we would like to know if we can use the video from the surveillance cameras installed at our company's service stations." This came to us in the form of a consultation with the IT department of a European petroleum company. We began with an interview about what sort of things they might be looking for.

The IT department, which had control over the systems and budget, wanted to explore the possibilities of AI, while observing all the laws and regulations pertaining to personal privacy, etc. No special needs had been requested from other departments; there was only a request from the security department that "we would like to be able to detect suspicious persons". This required showing if there was a possibility of the information actually being obtainable, and if then what was needed could be separated out.

First, we collaborated with the IT department to build a pilot system to acquire video from six of the service stations owned by the company. We used a deep learning framework, and carried out image analysis using vehicle attributes like vehicle type, license plate recognition, counts of the people in stores, etc. In some cases, the location where surveillance cameras in the service stations were installed was determined by law, and certain regulations did not allow them to be installed near fueling areas to avoid potential accidents like a fire. Since the quality of the images acquired differed depending on the surveillance camera, we used simulation technology to create simulated images of various angles and sizes. This was used for learning, and raised recognition accuracy on a weekly level. After trial and error, various information was able to be acquired even taking images from the video on cameras not installed in the most optimum locations (See Table).

In addition, information obtained from the image analysis could be matched with POS and employee card data, and data could be gathered and tracked daily for aspects like the distribution of fueling time and the ratio of vehicles arriving to the number of customers entering a store location. The head of the IT department that we worked together with said something quite interesting. "Let's gather user departments and conduct workshops".

Involving User Departments

The 2-day workshop included eight departments, including the oil department, food services department, marketing department, and so on. For the IT department and us as well, it culminated in showing the value gained from using AI. We prepared ① results of the detailed data analysis, ② a customer journey map, ③ and a practical demonstration. We also carefully prepared a scenario showing a way of proceeding.

First, in ① we showed data directly tied to business that could not be obtained from employee cards or POS data, such as comparisons between luxury car makers and premium oil stores and vehicles parked for long periods when pumps were closed at night. The points that people take away are thought to vary based on the participants, but here there was a feeling that the attendees' overall attitudes became more proactive. The springboard for the next part of the discussion was the customer journey map. Discussions tended to diverge across the multiple departments, since each had a different perspective relating to customers, but by summarizing the perspective of a customer from arriving at a store to leaving, departments were able to get outside their own walls and get over the language barriers between them, resulting in energetic conversation examining ideas.

We concluded with the practical demonstration. At one of the six service stations locations, we revisited the behavior of customers and managers, supposing scenarios with multiple different flows. For example, in a scenario for the security department, when a car a licence plate registered as a suspicious arrived, they experienced the use of a prototype we developed that would display tailored alerts on the POS terminals inside the store. Through these scenarios, we were able to clarify specific cases where AI image analysis could be used that may have at first been unclear, including demonstrating the possibilities for ① improving oil revenues, ② providing value-added services, and ③ heightening security.

Receiving an Innovation Award

We were very glad to receive an innovation award

from this oil company, which they hand out annually and involves over 1,000 partner companies. The reason we received the award was for "introducing new technologies that allowed for an awareness of business aspects that were not visible before, and in so doing, spread this awareness through the organization to the benefit of the company."

What we did was setup image recognition from the cameras using deep learning, and created visualizations from the incredible amount of data that could not be seen by human eyes alone. Although we had a certain level of expectations going in, ultimately the outcome far exceeded those. Even though we could not clearly see the destination, along the way we used trial and error to complete a small journey, which we believe is unquestionably a part of a digital journey.

Item	Analysis Specifics
Analysis Interval per Camera (analyzing while parked)	Every 10 seconds
Image Resolution	2048 × 1536 pixels
Number of Images Used for Learning (incl. images created via simulation technology)	20 million
False Recognition Rate	About 20%
Computer Used for Analysis	FUJITSU Workstation CELSIUS M740
Deep Learning Framework	Caffe (Open Source Software specialized for image recognition)
Software Used for Analysis	FUJITSU Technical Computing Solution GREENAGES Citywide Surveillance

Table: Overview of Surveillance Camera Image Analysis System at the Oil Company

C O N T E N T S

34	3-1 [Overview] Understanding the Digital Technologies Required for Our Journey
37	3-2 [Data Lakes] "Data-driven Business" Accumulating and Utilizing Big Data
42	3-3 [Artificial Intelligence] Practical Use of the Zinrai Artificial Intelligence API Digital Innovation via Co-creation with Client Companies
47	3-4 [Chatbots] Using AI to Revolutionize Customer Contact Points and Prioritizing Utility with CHORDSHIP
52	3-5 [IoT] Wireless Technology Spreading in Response to Needs and the Steady Evolution of Edge Computing
57	3-6 [Cyber Security] Japanese Companies Recognizing the Impact of "NIST SP800-171"
62	3-7 [Next-generation Computing] In the World of R&D Advancements in Next-gen Computing, What is the Potential of Combinatorial Optimization Using Annealing?
67	3-8 [OSS] OSS-driven Technology Trends involving Accelerating Service Development

PART 3

Solutions & Technologies

Technology is an essential tool needed on a digital journey. Of course, without understanding the fundamentals it cannot be effectively utilized. In this section, we will look at the next generation of computer architecture and explain application development technologies using OSS, including topics like Data Lakes, Artificial Intelligence, and Internet of Things, among others.

Understanding the Digital Technologies Required for Our Journey

Tomohiro Fukui Senior Manager, Service Technology Unit, Technology Strategy Office

From last year to this year, one technology that has been drawing a good deal of interest in the IT world is RPA (Robotic Process Automation). Digital Labor, a type of RPA, is already moving beyond the trial stage to full-scale introduction, changing how people work and environments with worker shortages.

Today vast number of digital technologies exists and RPA is only one of them. Please refer to Figure 1. Gartner published a "Hype Cycle for Emerging Technologies in Japan" in 2017. Seeing RPA is placed at the Peak of Excessive Expectations" periods, it is natural that it would garner interest; however, we can also see that there are a number of other technologies as well.

Observing Technology Broadly

Take for example, big data and the cloud located in the "Trough of Disillusionment," and the mobile technologies and legacy application modernization in the "Slope of Enlightenment." At many companies, these are not "finished" technologies; rather, they are set to become key

players from this point forward. More than a few readers must be thinking "the introduction of RPA without modernizing legacy applications would be bound to have a number of significant adverse effects". We can see how for the IT department that presides over the whole of a company's system, determining which technologies to prioritize and incorporate is a daunting task.

In recent years sharing economies were brought by today's major companies like Uber and Airbnb from America, as well as venture companies like Mercari from Japan have made it a common point to be trained in cloud, mobile, social, and big data technologies. Increasingly this applies to more than just venture companies. The major construction company Komatsu, in a group of four companies that also includes NTT DoCoMo, founded Landlog to properly utilize cloud, big data, and Internet of Things to gain an edge in business. Doubtlessly, open source software is also playing a major role for them.

Looking again at the hype cycle under the "Technology

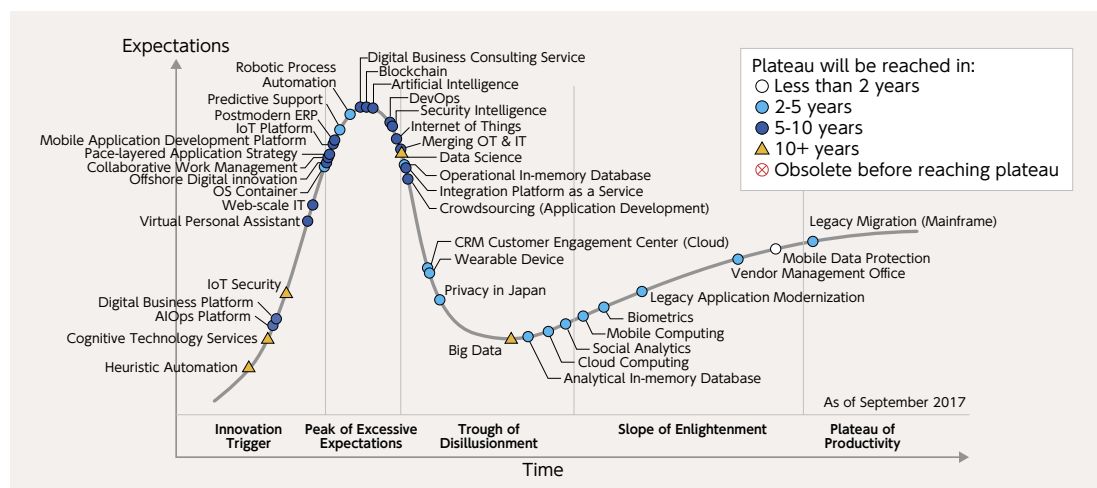


Fig. 1: Hype Cycle of Technology in Japan: 2017 (Source: Gartner)

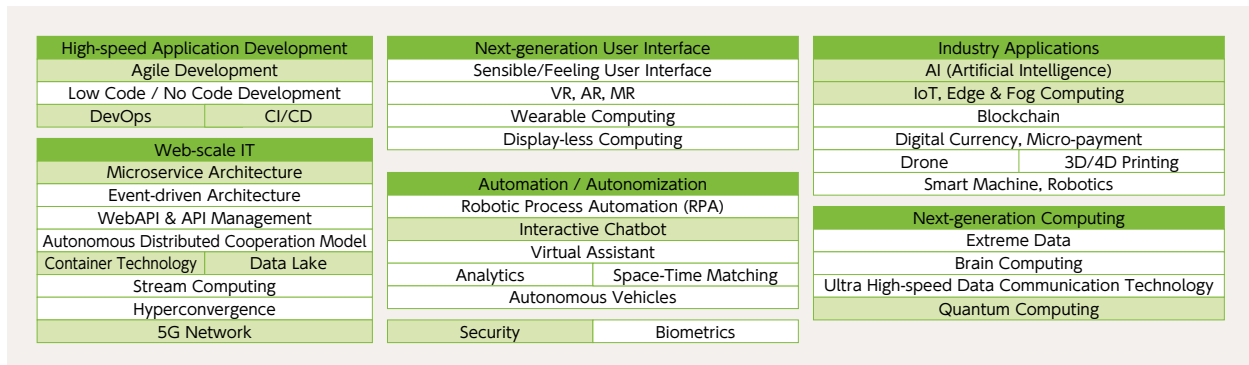


Fig. 2: Technology Components Overview (2018)

Trigger" portion, digital technologies focused on intelligent processing await, such as virtual personal assistants, cognitive technology services, etc. Looking at technologies in this way, we can think on potential applications in businesses, changes to the customer experience, and as a result, profit. Embarking on the digital journey is an inevitability now faced by every kind of company. Here in Part 3, we will highlight the technology that is indispensable for going on that digital journey.

Evolving Software Development Technologies

There are some technologies we should observe from a different viewpoint (**Fig. 2**). These include application development technology, technology related to user interfaces, and technology pertaining to the autonomization / automation of services and things, etc. In Part 3, technologies we are referencing / introducing are marked with light green, but we would also like to note that Fujitsu is also engaged in research and development of others as well.

Going in no particular order, let us begin by introducing technologies used to speed up application development. These are also a key to the service implementation phase of the service framework for co-creation, and under the banners of DevOps (integration of Development and Operations) and CI/CD (Continuous Integration and Continuous Delivery), they are aimed at reducing or automating the human work involved in the series of tasks in the development process: development,

testing, and operation.

Of particular note are the container-based virtualization technologies of Docker and Kubernetes. Fujitsu is participating in the Open Containers Initiative that is working towards standardization of this technology from the point of integration, and is accruing technical knowledge. The technology used for development and operation in this area is complicated and can be difficult to understand, but we have endeavored to explain it as clearly as possible in this section. As a basis for furthering digital business, having a general understanding of this technology is very important, so we invite you to take a look.

Next, let us discuss data lakes, which have a distinct sense of already being "underway." While various iterations of "the 20th century was the era of oil, but the 21st century is the era of data" have been passed around, there has not been decisive action to acquire, accumulate, and utilize data. Some reasons have been not knowing what data is useful and what is worth accumulating and storing; if it cannot be utilized, storing it will just be a waste; and time and resources are needed to construct a means or format for it to be utilized.

However, means for analyzing data, such as machine learning and deep learning, have made steady progress. When considering how to utilize data, it cannot be said that there is no critical data. Even data that appears at a glance to have little to no merit has potential to be of value in the future. This is where data lakes come into play.

Companies Should Begin with Internet of Things

On the digital journey, Internet of Things is also an important form of technology. Actually, it is a top priority. There are numerous use cases of IoT: for products, for facilities, even Internet of Humans! If we use the mobile devices of IoT for employees, it is easy to imagine how greatly the progress can be made in revolutionizing the way we work.

However, we hear things from work sites along the lines of "We already have reliable monitoring equipment in our factories and warehouses. Why would we need to work with IoT?" or "Preventative maintenance? At our company, our equipment and vehicles have scheduled maintenance. There is no issue with our rate of operation, so it isn't essential to us". This hinders the progress of IoT, but we must remember that the I in IoT is for "Internet" and not "Intranet." We must adopt a thinking pattern that considers the possibilities of what value can be created by opening up the closed off information at factories and offices to the outside.

Another point of interest is the next-generation architecture "Digital Annealer" developed by Fujitsu for solving the "combinatorial optimization problem." When it comes to the combinatorial optimization problem, D-Wave from Canada is also commercializing its quantum annealing computer, but there are some issues related to safety, etc. Using existing semiconductor technology, there are sample cases of digital annealers solving at 12,000 times faster than standard computers, and they are thought to have a greater practicality. From this point forward, the idea is to accelerate collaborative research with companies and organizations facing these issues.

Fujitsu's Work with Blockchains

Although we did not cover it in the preceding section on technologies, we should also touch on blockchains, which are positioned as a very significant technology. Fujitsu is a premier member of the Linux Foundation's

"Hyperledger Project," and we are committed to contributing particularly to the areas of safety, reliability, and usability. There is a keen awareness of the open-source blockchain technology Hyperledger's applicability in businesses involving finance, IoT, and supply chains, etc.

This is not limited to Hyperledger. Fujitsu Laboratories and Fujitsu Research Development Center in China have worked using one blockchain called "Ethereum", developing an algorithm to provide preliminary analysis of the risks of "smart contract" automatic transaction processing programs. We announced this publicly at BSC 2018 (Blockchains and Smart Contracts Workshop) held in Paris in February 2018. We believe this to be essential for the safety and reliability of smart contracts.

Elsewhere, since March 2018, FamilyMart which manages more than 3,000 convenience stores in Taiwan, along with Fujitsu and Fujitsu Taiwan, have been working in cooperation with local venture companies. We instituted a proof-of-concept that makes use of both blockchains and robots. The context of this technological development is that blockchains need not be limited to a basic technology used for virtual currency, but can have their applications expanded to include recording and managing rights and terms of contracts. We think this is disruptive technology that will completely revolutionize the flow of information and management using the internet.

Of course, this goes beyond just blockchains. Each of these various technologies, including VR/AR, 3D printers, digital currency, etc., has a kind of disruptive impact. While Fujitsu is a developer of technologies, we also contribute to companies by applying an expert's eye.

"Data-driven Business" Accumulating and Utilizing Big Data

Kazuo Mineno Professional Engineer, Digital Solution Business Unit Digital Application Group

Today you can often hear people saying "data is the 21st century's oil" and "enterprises now need to change course to being data-driven." However, how many people actively take these words to heart? For many, there is likely a feeling of "I get it but that's just for certain industries" or "that's just a meaningless phrase that IT vendors use to sell their goods and services."

Data is the 21st Century's Oil

A feeling I get from working with many companies, in more than a few, there is ongoing trial and error occurring with utilizing data. For example, consider demand forecasting of goods. In order to account for seasonal variation in predicting demand, existing sales data from multiple seasons is necessary, but in an extreme case, data from the previous year could not be obtained immediately. It may not be entirely accurate to call this trial and error, but it certainly can be described as a lack of cognizance concerning data. This is a situation that needs to be rectified without delay. Aside from a portion of companies who can maintain a competitive advantage through brand power or intellectual property, the phrase "data is the 21st century's oil" rings true.

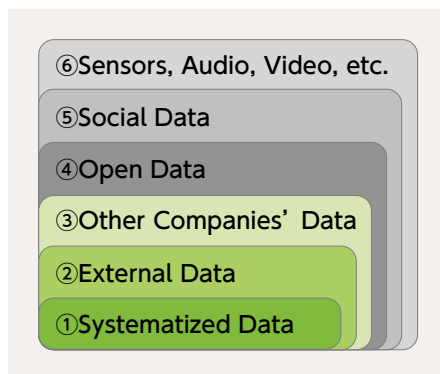


Fig. 1: As well as the amount, the variety of data has increased.

Further, IT has taken on a new appearance from 10 years ago to today, in order to make use of data, and it has become easier and cheaper to use high-performance goods and services. Customers and consumers carry smartphones, and various machines and goods have also started being equipped with Internet of Things devices. This is genuinely the era of big data / AI (Fig. 1). When thinking of how companies in direct competition and from different industries incorporate these to create advanced services and business innovations, it becomes apparent that following the traditional approach of relying on experience and intuition makes for a high possibility of some kind of predicament arising.

Therefore, in the following article we will look at what I have found in collaborating with clients, and I will explain the policies and procedures used to fully realize a data-driven business.

First, Overcoming the Idea that "Data Analysis is Expensive"

One of the major obstacles in actualizing data-driven business is a paradoxical lack of data. Since data storage was once so expensive, in the past it was not possible to preserve data that would not clearly be useful for analysis in the future. ETL tools for converting data into a form useful for analysis and data warehouses (DWH) for analyzing tens of millions of data points within a set time were also expensive. Data with a seemingly high influence or utility and sales data was commonly stored and used, but aside from those, even if other data was acquired, it was not uncommon for it to be discarded.

These had a clearly defined purpose that led to strictly defined prerequisites, and systems were introduced for

data storage and analysis optimized for these requirements; this could be called a "goal-driven" approach. Incidentally, thinking this alone was sufficient became another obstacle down the road. Even though decision making based on veteran experience and intuition is a thing of the past, when accountability can be ensured through typical analysis, major discrepancies seldom occur. Should they not produce results, reasons typically are invented, and people also tend to just say they had bad luck.

However, in this so-called era of data, where today a 1TB HDD costs only around US\$50, this is not appropriate. Even if whether certain data will have value is unknown, the acquired data is saved so it may be utilized. Even if not useful for the particular group the data belongs to, it may prove necessary for other people, divisions, and companies. An easily recognizable example is the nonfiction novel *Moneyball* (also adapted into a film). In this story a major league baseball team (Oakland Athletics) with less funds than their competitors becomes a strong team using a method of data analysis called Sabermetrics, which today has spread beyond just baseball into other sports such as soccer.

Naturally, this has not remained only in the sports arena. This can also be seen reflected in the business world. One example is the well-known ridesharing service Uber. Based

on daily ride history data, they use a pricing scheme called "surge pricing" that dynamically adjusts ride fees according to supply and demand. This setup brings benefits to both users and drivers, and is regarded as one of the driving forces behind their growth. In both Japan and the U.S., many internet companies track the mouse-usage data (or touch history on screen for smartphones) of their users, and store and analyze all of it. Naturally, this results in a tremendous amount of data, but they are well aware that they will lose their competitive edge if they do not do this. This idea that so long as there is data something can probably be done is the approach we call "data driven."

"Data Lakes" are Effective for Data-driven Business

So, what should companies do to achieve this data-driven approach? The answer is decidedly "data lakes," which we think provide the platform for accumulating data. Regardless of whether or not it serves an immediate purpose, data is accumulated that can likely be utilized for various tasks in the future. Unlike data warehouses, which store structured data with relatively clear value, a data lake also accumulates unstructured data such as voice and image data, machine operation logs, sensor data spanning a long period, etc. The image is that of a lake into which the waters of many rivers flow (in this case various data) (Fig. 2).

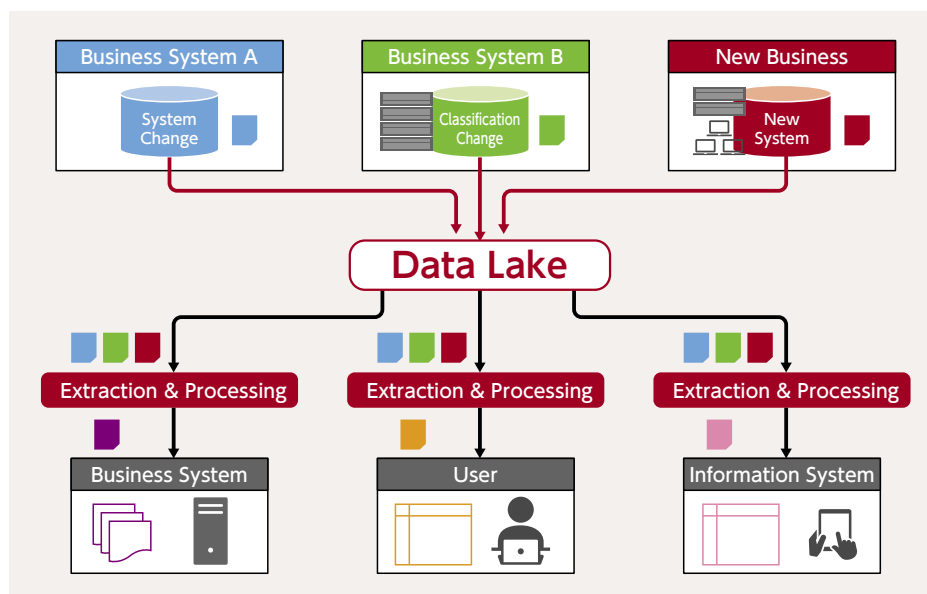


Fig. 2: Image of a data lake. Stores data generated by various systems as it is. User decides how it is to be used.

The user (group) needs to determine how to use the data accumulated in the lake. To do that, no data processing should be done before the data is accumulated in the lake. However, based on the nature of the information source, they can be arranged using say character codes chosen for each information source, rules made based on file names, attributed timestamps, folder management, etc. This kind of metadata maintenance is needed to keep everything from becoming an overstuffed trash can of miscellaneous data.

On the other hand, in addition to structured data in the data lake, since it has enormous storage capacity it also accumulates various data that includes unstructured data (scale-out). While this has become more cost efficient, a considerable amount of investment is necessary, but since this is needed by the business, a direct ROI (Return on Investment) should not be sought. This would be comparable to say the office buildings and furniture needed for business operation.

Five Requirements for a Data Lake

On the user side, the data needed for each goal is selected and extracted from the data lake, and then processed and analyzed to suit that objective. For instance, in "adding temperature data" during the process of examining analysis results in a demand

forecast, the data to be used in the subsequent analysis is taken from the lake. You might also use time series data of keywords that were subjects of discussion on social media. In order to perform repeat trial and error as would be done in this example, various data is accumulated in the data lake.

Consequently, in many cases it takes time and effort to convert the data extracted from the data lake into an analyzable form. Since it is not unusual to have a one-time case in processing on the user side performed via trial and error, means to reduce the labor in the area are needed. Based on the data lake requirements mentioned, we think the following five items are important.

- **Flexibility:** Data can be accumulated from various information sources, and various types of data can be flexibly added.
- **Registration Performance:** Data registration from various information sources is easy and can be accumulated efficiently.
- **Processing Performance:** It is possible to process the large amount of accumulated data at high speeds.
- **Data Sharing:** Data sharing with various systems on the user side is simple and efficient.
- **Scale-out:** Data capacity, performance, and functionality can be expanded in stages to meet needs.

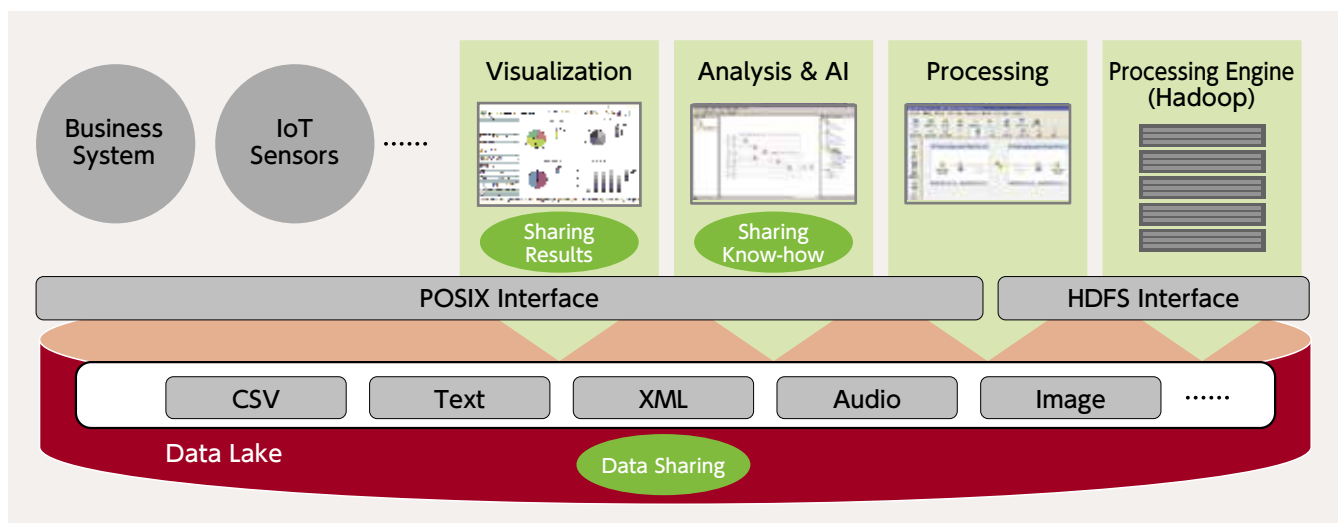


Fig. 3: Overview of the Data Lake in Fujitsu's Data Analysis Solution "ODMA"

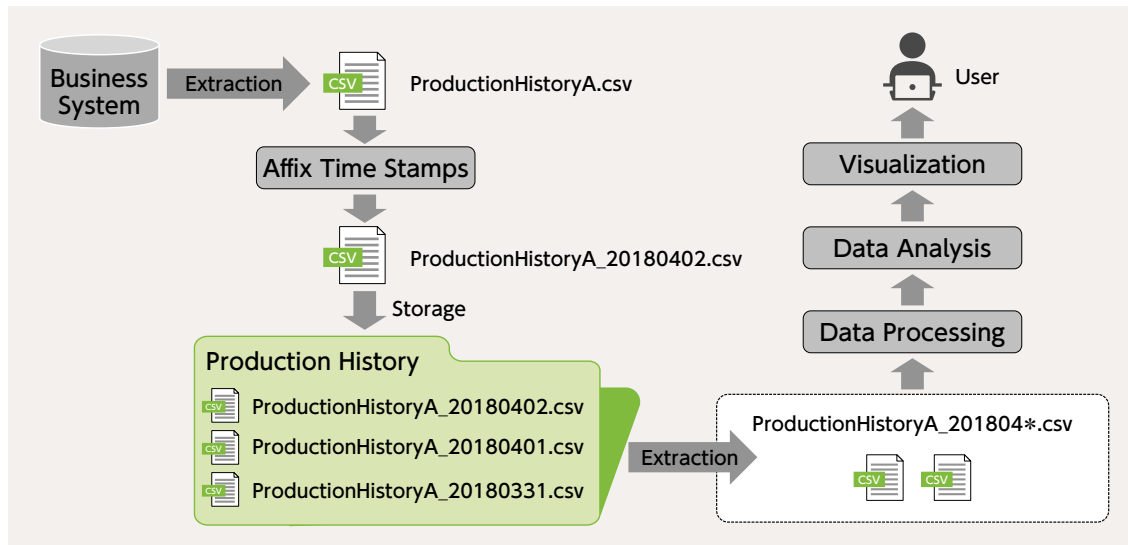


Fig. 4: Collecting and storing data in a natural way

Implementing Data Lakes is more than "HDFS"

Methods for building data lakes are not as established as data warehouses, which is why such ambiguity still remains as to the essential features, and there are various circumstances for each vendor company, including the way they think.

Let us look at the features of HDFS (Hadoop Distributed File System), OS file systems, and cloud storage used as data lakes.

HDFS is a distributed file system installed on "Hadoop" that processes large amounts of data in short periods of time by distributing data on multiple servers and using parallel processing. It is often used in combination with the distributed processing technology "MapReduce Framework," which is another component of Hadoop.

Using very generic and inexpensive servers, a large amount of data can be accumulated, and using MapReduce, high-performance processing can be put into place. Since scale-out is also easy, this is often used to build data lakes. Other data lakes comparable to Hadoop include Hortonworks, Cloudera, and MapR, which all have commercial distributions. Starting with "Spark," there are also many OSS tools that can work in

conjunction with them.

Still, there are file systems suitable for constructing data lakes more simply that do not use technology like Hadoop. Unlike Hadoop, data such as audio and images can be stored regardless of format. They are only able to deal with an increase in volume by adding storage, and they benefit from being able to be directly accessed via various applications. Cloud storage has similar features to a file system, but data transfer and processing performance depends on networks and cloud centers.

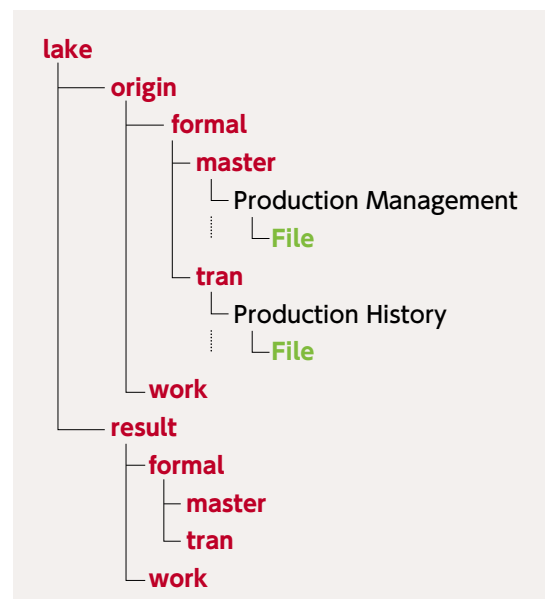


Fig. 5: Example of Folder Hierarchy

Fujitsu's ODMA Employs a File System

Fujitsu's data use and application base "ODMA (Operational Data Management & Analytics)" adopted a file system to use for a data lake (Fig. 3). By using Fujitsu's ETERNUS as the storage device, the system features improved performance by using decentralized arrangement of data and cache control, as well as reliability via redundancy. It follows POSIX for its Unix-based filesystem API protocols, and from the outside looks like a Linux filesystem. It also has an HDFS API and can process using Hadoop's MapReduce.

This setup is a little complicated when compared with a simple setup using Hadoop, and requires the specialized storage, ETERNUS. However, it can be used as a massive network filesystem directly connected to the OS from the general system, and it incorporates the benefit of being a data lake that can also use Hadoop.

Important Points when Operating a Data Lake

Massive amounts of data will continue to accumulate in the filesystem, and there are several points to keep in mind while maintaining and operating it.

- (1) Data files of the same type should be aggregated into one folder, and properties of the data such as various details and information source, etc. should be listed in the metadata file.
- (2) There should be rules for naming files. For example, in Fig. 4 "Production History" is a detail of the file, and "A" indicates that there is a product labeled A. There is also a time stamp given for the production history. By doing this, data can be clearly specified via its file name.
- (3) Folders should have a hierarchy with names indicating the nature of the data stored in them. An example of a folder structure is shown in Fig. 5. As the author, I recommend the folder configuration using the red letters. The "tran" label contains

business history as journal data. Under that, for each type of journal data like "production history", a folder needs to be created and the data files stored. As for the other folders, "formal" is for data to be publicly released, and "work" is for storing data still being organized.

Starting Small, Collecting and Using Data

At the beginning, I said "in more than a few [companies], there is ongoing trial and error occurring with utilizing data." "How can we break free of our current situation?" is the point where the small start emerges. If actual data is not analyzed, then you will get no results, and it is difficult to make a significant investment when you cannot predict the outcome. Even more problematic than that, while taking time to build a large scale system, data that should be stored is lost. When data in a business system becomes unnecessary for conducting business, it is often deleted, and once that data is lost, it cannot be recovered.

In addition to Fujitsu's ODMA, many other data lake solutions also scale-out. That is to say that a small start is possible. If data that is a source of value is collected as a data lake, the mechanisms to utilize it can be added at any time, and I would invite others to make a small start with the knowledge they can be changed.

Practical Use of the Zinrai Artificial Intelligence API

Digital Innovation via Co-creation with Client Companies

Kaoru Chujo Head of AI Services Business Unit
Ryo Tanimoto Manager, Frontier 2 Division, AI Services Business Unit.

In February 2011, IBM's cognitive system "Watson" won against humans in the popular U.S. quiz show Jeopardy! SoftBank's robot "Pepper" that uses emotion recognition was announced in June 2014. Primarily developed by Japan's National Institute of Informatics, "Tou Robo-kun" received a standardized score of 57.8 on the Shinken Simulated Exam, and showed that it had reached a level where it would be able to enter a high-level private university as of June 2015. Then, "AlphaGo" developed by DeepMind under the umbrella of Alphabet Inc. in the U.S. defeated the best professional shogi player in the world in March 2016.

As these events demonstrated the possibilities of Artificial Intelligence, AI investment exceeded \$5 billion

worldwide (according to the Japan External Trade Organization), and the third AI boom had arrived. Driving this boom was "Deep Learning (DL)", which extended directly from neocognitron proposed by the Japanese engineer Kunihiko Fukushima. Although there are challenges where intelligence and reasoning cannot be explained, this has proven excellent at recognizing images and sounds, etc.; R&D and applications are progressing throughout the world in areas like image recognition for automated driving, diagnoses using medical imaging, facial recognition for criminals (in China, etc.), among others. Since Deep Learning can be applied to language recognition when it is devised to an appropriate model pattern, it is thought that it will contribute greatly to improving the accuracy of Google Translate.

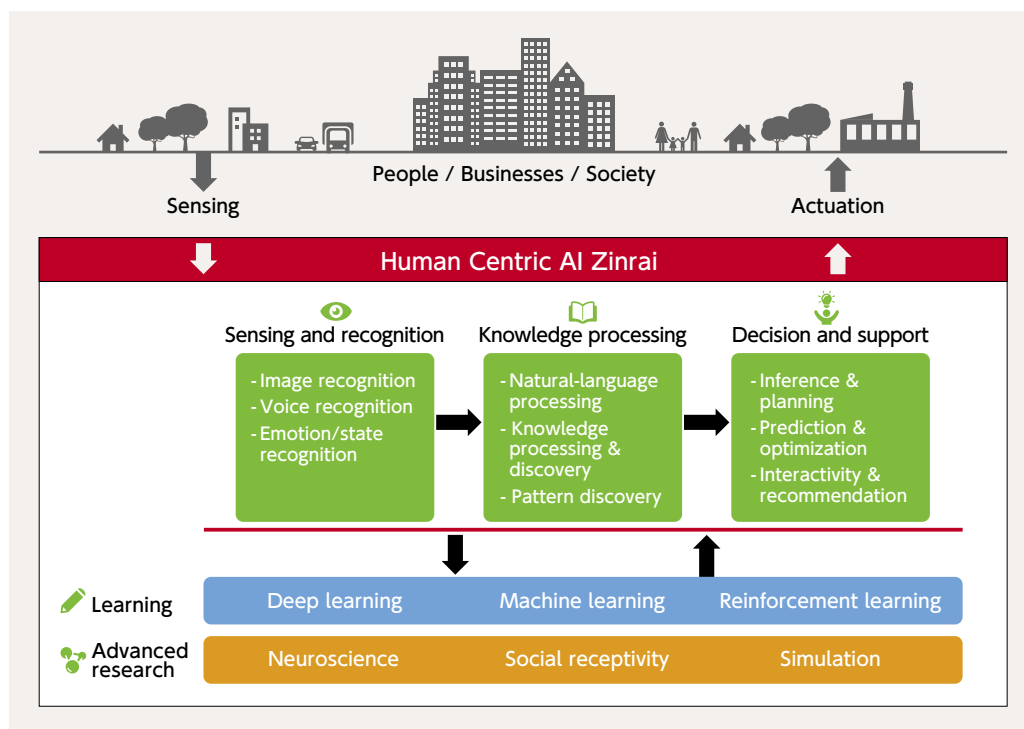


Fig. 1: Concept of Zinrai

However, it is also true that at present applications are still limited. Including statistical machine learning and natural language processing (NLP) that were being research before DL came along, the technology has not been able to be applied in situations requiring safety and certainty, and it has remained in a supplementary role to humans. It is said to be useful for case where "general accuracy is okay," but, it does not have the benefit to be applicable and considerate such as the human ability.

There is however no doubt as to its enormous potential. Even at Fujitsu, since the 1980's Fujitsu Laboratories has been working on knowledge bases, Natural Language Processing(NLP) and recently began working for Deep Learning(DL) in order to bring service which will be

useful for our customers. Hence, we announced our AI technology brand "Human Centric AI Zinrai" in November 2015 (Fig. 1). Will explain how API of Zinrai derived from the concept of being "as fast and dynamic as lightning".

The Functional Composition of Zinrai 3 Categories of API

AI can be understood as "realizing a part of human intelligence using machines and software". Humans take in their surrounding environment, and while referring to past memories and records, judge what actions they should take. We configured Zinrai's functionality while thinking about this. We established three categories

Type	API Name	Description	AI Technology
Perception & Recognition	Image Recognition API	The image of an object or scene is input, and it recognizes what is in the image. It returns text data of identified candidates and accuracy (estimated results list). There are the following types: ·Image Classification: An image with one object is input, and it identifies what it is ·Scene Classification: An image of a scene is input, and it identifies what kind of scene it is ·Object Recognition: An image in which multiple objects appear is input, and it identifies what they are and where they are located. Position coordinates are also included in the estimated results list.	DL (*CNN)
Perception & Recognition	Handwriting Recognition API	A handwritten character image for 1 Japanese character is input, and text data (estimated results list) describing the character and accuracy is returned. At present it can recognize Shift JIS, JIS level one kanji, alphanumeric characters, symbols, hiragana, and katakana. Since this API is a basic API, input needs to be divided into 1 character at a time.	DL (CNN*)
Perception & Recognition	Voice/Text Conversion API	Audio data of up to 1 hour in length is input and converted to text. Works for Japanese and English. Also supports natural conversation (speaking freely) and undefined speakers.	Machine Learning Base Algorithm
Perception & Recognition	Speech Synthesis API	Character data is input and synthesized speech is output. Works for Japanese (2 male voices, 2 female voices) and English (1 female voice). For Japanese, the pitch, the use of high-frequency emphasis, and intonation strength are adjustable. A dictionary for customization can be prepared with up to 3,000 registered words.	Proprietary Algorithm (Corpus-based)
Perception & Recognition	Emotion Recognition API	Japanese audio data is input, and the degree of satisfaction is estimated from the pitch of the speaker's voice and patterns in how it changes. Responds with a satisfaction score based on 1-second units (expressed as 0 to 100) and text data denoting sections of high satisfaction and sections of high dissatisfaction.	Machine Learning-based Analysis Algorithm
Knowledge	Natural Sentence Analysis API	Japanese text is input, and the following 3 types of processing are performed (patent pending): 1) Place Name & Coordinate Estimation: Estimates location name, address, and coordinates (longitude and latitude) from input statement. E.g., "Takoyaki in Minato Ward" yields "Place: Minato Ward", "Address: Minato-ku, Osaka", and "Longitude: 135.5", Latitude: 34.7" 2) Proper Noun Extraction: Can identify and extract people and place names from input sentences. E.g., "Meet Mr. Miyazaki in Miyazaki Prefecture" yields the result "Meet Mr. Miyazaki [person] in Miyazaki [place] Prefecture." In addition to people and place names, a standard model can be used with advance learning for 10 items. At the user company, additional learning for each item and learning for new items is possible. 3) Sentence Classification: Classifies input sentences based on preset labels, responding with the label and its accuracy. E.g., "Power outage due to storm" yields a positive value for the case of "emergency" and a negative value for the case of "general."	Machine Learning-based Proprietary Algorithm
Knowledge	Knowledge Information Structuring API	API for structuring the text in documents. Keywords characterizing documents are extracted, and based on those keywords, they are structured based on measuring the similarities between the documents. The created structured knowledge data can be used by the Knowledge Information Retrieval API.	Proprietary Natural Language Processing Algorithm
Knowledge	Knowledge Information Retrieval API	Using specified structured knowledge data, searches for information close in meaning to input keywords. A search string is input, and using the structured knowledge data generated by the Knowledge Information Structuring API, documents are retrieved that are close in meaning to the search string. Since the search is based on similarity of meaning, it is possible to search documents that do not contain keywords. For example, even people with little experience related to specialized technical language can find specialized documents using simple language.	Proprietary Natural Language Processing Algorithm
Judgement & Support	Predictive API	Creates a prediction model based on past data, and predicts future data. Once a prediction model is created, the model can continue to be reworked using new data, improving prediction accuracy.	Proprietary State Space Model-based Algorithm

Table 1: Basic APIs Provided by Zinrai Platform Service

*CNN: Convolutional Neural Network

Type	API Name	Description	AI Technology
Knowledge	Semantic Search by Specialized Field API	Structures large capacity documents, and searches words (keywords) and sentences (natural sentences) for text close in meaning. Since the search is based on similarity of meaning, it is possible to search documents that do not contain keywords. For example, even people with little experience related to specialized technical language can find specialized documents using simple language.	Proprietary Natural Language Processing Algorithm
Knowledge	FAQ Search API	Based on input question, searches appropriate FAQs for responses and displays them in order of relevancy. Search accuracy can be improved by learning from past response history, related documents such as manuals, and feedback data on search results.	Machine Learning & DL-based Proprietary Natural Language Processing Algorithm
Knowledge	Interactive Bot for FAQ API	Using a learned model created based on dialogue history data, draws out information in an interactive format and derives appropriate responses. Since the dialogue is conducted using natural sentences, there is no need for users to think of keywords. Since it remembers interactions with users, it is possible for the API to refer back to past dialogue histories. Also, new learning from collected dialogue histories improves response accuracy.	Proprietary Natural Language Processing Algorithm
Judgement & Support	Demand Forecasting API	Predicts demand and sales of goods sold at stores. In creating a sales forecast model, can learn from POS data, as well as external input data, such as weather and event calendars. By continually reworking the model with new data, can improve most recent prediction accuracy	State Space Model-based Proprietary Algorithm
Judgement & Support	Company Information Search API	When searching using company names and addresses, various information related to that company can be acquired simultaneously. Using the laboratory's own technology, the same judgements can be made automatically and integration can occur using the user's company's company information (e.g., transaction data) and Fujitsu's company information under open data, allowing for a quick and accurate grasp of the latest information concerning business partners.	Proprietary Linking (same judgements, integration) Algorithm

Table 2: Purpose-specific APIs Provided by Zinrai Platform Service

and took an approach to provide a function for each: ① perception & recognition, ② knowledge, and ③ judgement & support.

Perception & recognition is the collection of image and audio data obtained through the use of sensing from the company and society, and these are the functions for perceiving and recognizing meaningful information. Typically this is implemented through Deep Learning.

Knowledge deals with information such as web pages and office documents. It is a function group for acquiring knowledge by extracting the names of people and places from textual information, associating people's names with organizations, and discerning the relationship of the people to the companies they belong to, etc. Implementation involves the use of Natural Language Processing technologies, such as morphological analysis, syntactic analysis, semantics based on statistics, and so on.

The third category, judgement & support, is a function group that uses past data to make predictions about the future, and provides support to people's judgements by pulling out the optimal combinations. This is achieved by combining statistical classification algorithms and machine learning, such as Bayes classifiers, the method of least squares, and Support Vector Machines.

In Zinrai, these three function groups are provided as API. As of May 2018, we offer a total of fourteen basic APIs and purpose-specific APIs (Table 1, 2). However, it is not yet complete, and we are expanding the functions of the API.

Let me give an example. An API for handwritten character recognition takes in the image data for one character (maximum 4096x2160 pixels), checks the presumed character (actually the character code) for accuracy and returns that information (Fig. 2). In order to distinguish handwritten names and product names, it is necessary for each character to be separated out and have a repeat check for just the number of characters; this processing needs to be handled on the application side. This takes time and effort, but it is a simple process that begins by first providing basic processing that performs single character recognition.

Zinrai Deep Learning Works to Speed Up Learning Performance

Table 1 shows a list of basic APIs, many of which involve a model that uses learning to resolve a task. However, for applications for companies, there are some instances where a user (company) will be in a tough spot if they cannot provide their own data for learning. Particularly when detecting defective products in a

production line, it is clear that accuracy will not improve by using the image recognition API, and instead needs to receive learning using image data of good and bad products. Although not in Table 1, Zinrai offers functions where learning can be done from scratch. We also offer services that cover preparation work, such as data processing, preparing learning data, and model creation, so that companies can make a smooth transition to using AI.

In relation to this, let us also introduce the machines behind the scenes. Zinrai's DL platform adopts NVIDIA's latest Graphics Processor Unit. This is orthodox, but Fujitsu's parallel supercomputer technology is also applied to construct the platform. The reasons for this are as follows. First, GPUs that are installed onto one server have an upper limit, and in order to use any GPUs, multiple servers need to be interconnected.

However, since DL calculates sequentially using previous operation results, unexpected latency occur due to variations in server computation times and the time it takes for computation results to be transmitted. Even if the number of servers is increased, it is not always possible to speed up learning performance. This is solved using parallel technology, and by configuring a multi-node environment specialized for DL using GPUs (up to 64 GPUs), we have achieved one of the world's fastest learning performances in internal evaluation.

On this infrastructure of the GPU servers and storage,

we operate open-source DL frameworks, such as Caffe and TensorFlow. In particular, for Caffe we developed and provide Distributed Caffe to optimize the timing of data transfer between memories to improve performance in the GPU parallel environment. There is also a means to help it progress by learning efficiently operating it using a GUI from a web browser.

Natural Language Processing Using Stacks

As shown in Table 1 and 2, the AI technologies adopted by Zinrai is not limited to DL. NLP is used for the purposes of chatbot dialogue and extracting important elements from writing. NLP is basically morphological analysis that breaks down natural sentences into parts of speech and conjugations; from the results of the morphological analysis judges if it is declarative or interrogative sentence using syntactic analysis; uses semantic analysis to assign the meaning of the sentence from the meaning of the words; then uses context analysis to grasp the meaning of the sentence from a selection of numerous sentences; and comprises a dictionary.

Take remarks made on a social network as an example. It will conduct analysis to extract what the focus is while considering the context of what comes before and after the central comments, conversing with users who accessed a product showcase site using natural language. This technology is indispensable in doing

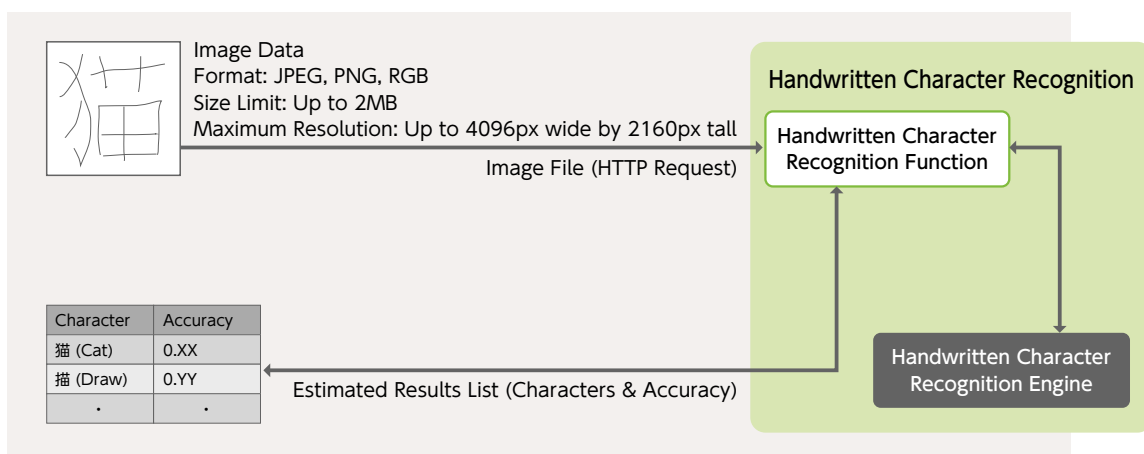


Fig. 2: Example of a Basic API that Recognizes Single Characters in Images of Handwritten Characters

things like constructing a chatbot to provide product information.

Fujitsu has been researching and developing NLP from awhile back, and we have developed and provided many systems. One of these is technology for the extraction of named entities and can distinguish 10 frequently used named entities with high precision (person's name, telephone number, postal code, organization name, location, object, time, date, amount of currency, ratio).

Based on approximately one billion words of text information, it uses statistical machine learning to process the characteristics of language use, such as the combination of postpositional particles following nouns (in Japanese) or words used in conjunction with one another. This can be used to protect personal information by automating the task of deleting a person's name from a text. It also goes without saying that in the example of a name like "Miyazaki", the system will automatically distinguish whether that is a person's name or a place name.

Although this may seem somewhat niche, we also developed a technology for SNS information analysis that can infer from several sentences whether statements made on SNS are an incident or an accident. Text can be classified using rules and dictionaries created from learning data and term dictionaries, and this acts as a text labeling engine based on statistical machine learning.

Incidentally, in order to use above explained API, "FUJITSU Cloud Service K5" usage contract is required. In case of serious usage, there will need to be compensation paid; however, of course initial trial usage is also possible. Please contact us for any interest.

Co-creation between Companies and Vendor AI Engineers

By using AI, the impossible becomes possible. This is the main reason that interest and speculation have

been drawn to AI, but it also presents some challenges. Naturally, you do not typically think about what you are not able to do, and it is only after someone else in the world has done it that you realize "Oh, I can do that?" However, at that point you end up already one or two steps behind.

Another problem is taking on something and not quite being able to reach as high as you had hoped. For example, the target of NLP is natural language, which includes many ambiguities. Even our native languages can at times prove ambiguous, and of course new words are also always appearing. Japanese in particular is a language that is premised on certain common knowledge when it is spoken and written. Even if NLP and DL are combined, without a kind of common sense, the system will not understand a phrase like "reading the situation". The reality is that the wall that AI has yet to climb over is still fairly high.

It is precisely because of problems like these, that we think co-creation between companies and vendors like Fujitsu is equally as essential as the digital journey. In this section, we have focused mainly on explaining Zinrai, but we should also note that Fujitsu is not clinging to just Zinrai. Today, various research and development related to AI is being conducted all over the world. Since our top priority is to achieve greater results, it is essential we incorporate results. However, to that end, we need knowledge to identify what is and what is not innovative technology, which is why we are grappling with AI ourselves.

On the other hand, in addition recommending the use of Zinrai's APIs, etc. to companies, we would like to recommend collecting data (see Part 3-2). Even now data can be collected on interactions with customers on the web and through call centers, the operational data for factory facilities, the travel path data for vehicles, and the traffic data on the internal network, etc.; along with installing surveillance cameras, etc., if you work to tackle IoT, new data can be obtained. This will lead to business innovation utilizing AI.

Using AI to Revolutionize Customer Contact Points and Prioritizing Utility with CHORDSHIP

Yoichi Kurachi | General Manager, Digital Transformation Business Group

There has been an increase in interest for how Artificial Intelligence can be applied to contact centers. Telephone operators field an incredible range of inquiries from (potential) customers, requiring an impressive level of effort. Ideally, a portion of this load can also be borne by AI by using, for example, chatbots. All involved in this area have been giving this some thought.

The question becomes what contact center tasks can you use AI for? We can consider two categories: ① questions, including customer requests such as "I would like

information about products" or "I want to know how to use the product I purchased"; and ② procedures, such as "I want to cancel my contract." In these areas where inquiry details and responses have established boundaries, that is when we are able to apply AI (Table 1).

However, even with ① questions, in instances of inquiries that involve claims or complaints, the story can vary. Appropriate responses are then required that take into account what the customer wants to say and how that customer is feeling. Although AI can doubtlessly be

Industry	Service	Class	Overview
Finance (Credit Cards)	Inquiries about credit cards	B2C	Automated responses to frequently asked questions about credit cards
Finance (Bank)	Bank customer support	B2C	Automated responses to frequently asked questions about banking services
Finance (Bank)	Automated responses for bank location guidance	B2C	Bank branch guidance
Finance (Securities)	Automated responses about securities agency services	B2C	Automated responses to frequently asked questions about stocks and securities
Finance (Life Insurance)	Life insurance customer support	B2C	Automated responses to frequently asked questions about life insurance
Finance (General Insurance)	Automated accident reception for general insurance	B2C	Automated reception for general insurance accident reception, automated responses to inquiries
Finance (General Insurance)	General insurance agent help desk	B2B	Automated responses to questions frequently asked of agents
Manufacturing	Automated responses for equipment repair cost estimates	B2C	Automated responses of estimated repair costs for broken equipment
Manufacturing, Retail, Information, etc.	Support for products, services, etc.	B2C	Automated responses to questions about products, services, etc.
Electricity, Gas, Water	Inquiries about stopping/starting electricity, etc.	B2C	Automated responses to questions about suspension and providing of services related to changing residence
Railway	Lost and found support center	B2C	Automated responses to questions about property lost using railway services
Local Government	Garbage guide	G2C	Automated responses to questions about separating out garbage and disposal of large items, etc.
Local Government	Tourist information	G2C	Tourist information for visitors to Japan
General	Internal IT help desk	inB	Automated responses to questions about IT items such as Office 365, etc.
General	Human resources service desk	inB	Automated responses to questions about personnel affairs
Manufacturing	Initial judgement of classifications	inB	Collect prior information related to export classifications
Manufacturing	Specialized internal help desk	inB	Automated responses from specialized IT help desk

Table 1: Examples of Main Applications of "CHORDSHIP" as a Chatbot for Call Centers

applied, it is important to decide what range of tasks the AI should be applied to.

Which types of AI is Suited for Contact Centers

While examining the evolving state of technologies, it is also important to select the most appropriate AI method. The driving force behind the current AI boom is a technology called Deep Learning. This is an extremely capable technology that increases in accuracy as it continues to learn (in correlation with more data being used), and while there are chatbots and other contact center solutions on the market based on DL, they have many problems, making them seem a bit premature to us at Fujitsu.

Take the case of a new product coming out in three months. DL requires a large amount of training data to be prepared. However, since the product has not yet been released, no such datasets exist. While a person could try to forcibly construct such data, it would likely not be wholly accurate. Additionally, when DL happens to have an incorrect response, it cannot immediately be tuned to give the correct one. Accurate training data must be re-entered, and it must be allowed to learn.

Of course, this is just an example of a very simple DL. Just as a hypothetical situation, suppose you created a DL that could respond with language very similar to everyday conversation using massive amounts of data and significant computing resources. In a form consistent with that DL, a specialized DL could be made from learning about a particular industry, products, and the procedures for services, which would have a high possibility of responding in a manner close to that of a human.

As a matter of fact, Amazon.com, Google, and Microsoft, among others, are known to be working on a DL like as aforementioned above. However, the requirements of large amounts of data and machine power cannot be said to be optimal at present for contact centers, though they may be in the future. Above all, when it comes to

complex inquiries and claims, having a human operator respond is desirable. Bearing this in mind, actual utilization should work with a relatively small amount of data, and tuning should be possible on site.

Structuring for High Response Accuracy

That being the case, what actual solutions are we looking at? In responding to the items we would consider ① questions, in essence the question from the user is used as a key to search and retrieve potential answers. However, this must be approached differently than with a Frequently Asked Question site. Users (customers) engaging with a chatbot or operator behave differently than when viewing a FAQ site. When inputting a question and searching a FAQ site, common practice is to enter one or a few words with necessary spaces in between corresponding to the topic. When chatting, more natural language is used.

Naturally, the answers are also presented differently. In a FAQ search, multiple potential answers can be given as search results, but with a chatbot, one single answer is required as a response. To that end, the top priority is to find a highly precise answer using natural language. In 2017, Fujitsu released the chatbot CHORDSHIP, which uses a rule base and natural language processing technology to meet these needs (**Fig. 1**). To be specific, there is ① a rule base for narrowing down and guiding using dialogue, ② slot filling that fills in internal forms while talking with the user, and ③ a retrieval method that uses the user's question sentence as a key to search for corresponding answers.

Implementing Results of Natural Language Processing

Consider an instance where the narrowing down process reveals that the inquiry relates to a breakdown or defect; the chatbot must obtain information such as the product's model number, symptoms of the product failure, etc. To do this, the chatbot will ask something like "Could you please input the 11-digit model number

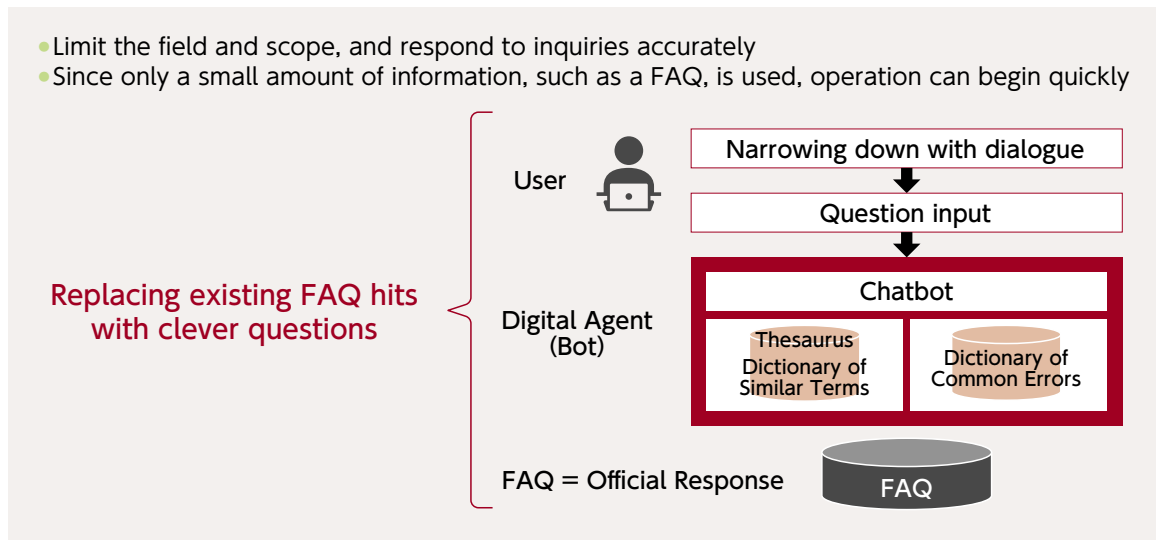


Fig. 1: Basic Configuration of CHORDSHIP

on the bottom of the product?" so the user will provide the necessary information.

The most important aspect is the retrieval method used in part ③. Following the same example, a potential user response might be "I think the model number is ABC12345678. Does that work?" While this may seem simple, using this information can be more difficult than one would expect because there can be various responses to precisely reading "ABC12345678." CHORDSHIP makes use of various methods, including "partial match retrieval," "distance calculation between sentences," and "text classification."

A "partial match retrieval" is often used for any search, but will tend to return lots of hits, so it can be difficult to return a single answer. "Distance calculation between sentences" uses various methods, such as Levenshtein distance, Jaro-Winkler distance, and gestalt pattern matching. For "text classification", approaches worth mentioning include using a stochastic (probability) model for classification (e.g., Naive Bayes), using statistical information for classification (e.g., TF-IDF), and using neural networks for classification (e.g., Doc2Vec). In order to achieve high accuracy in the responses, how these methods are combined is what becomes important.

In addition, the prerequisite for this kind of functionality is maintenance of a dictionary. At Fujitsu, we have a Japanese dictionary database of over 12 million terms that includes synonyms, derived words, and so on that is applied to many different solutions, including CHORDSHIP. As previously mentioned this DL approach is being developed and provided as a part of Zinrai, and we are planning to utilize in CHORDSHIP if we find DL superior than other technologies in comparison.

As you can understand based on the discussion thus far, CHORDSHIP chats with users by using improved FAQ information as a base. While it cannot comply to small talk or a user's emotions with great finesse, on the contrary the lead time to implement is short, and functionality can be added easily even after operation has begun. We believe that in terms of practicality, it has sufficient functionality and performance. Still, there are some follow-up thoughts to share.

The Importance of an AI and Human Hybrid

When it comes to the work of a contact center, there are questions and complaints with a degree of difficulty that only people can respond to. A poorly executed response can lead to angering customers and potentially significant

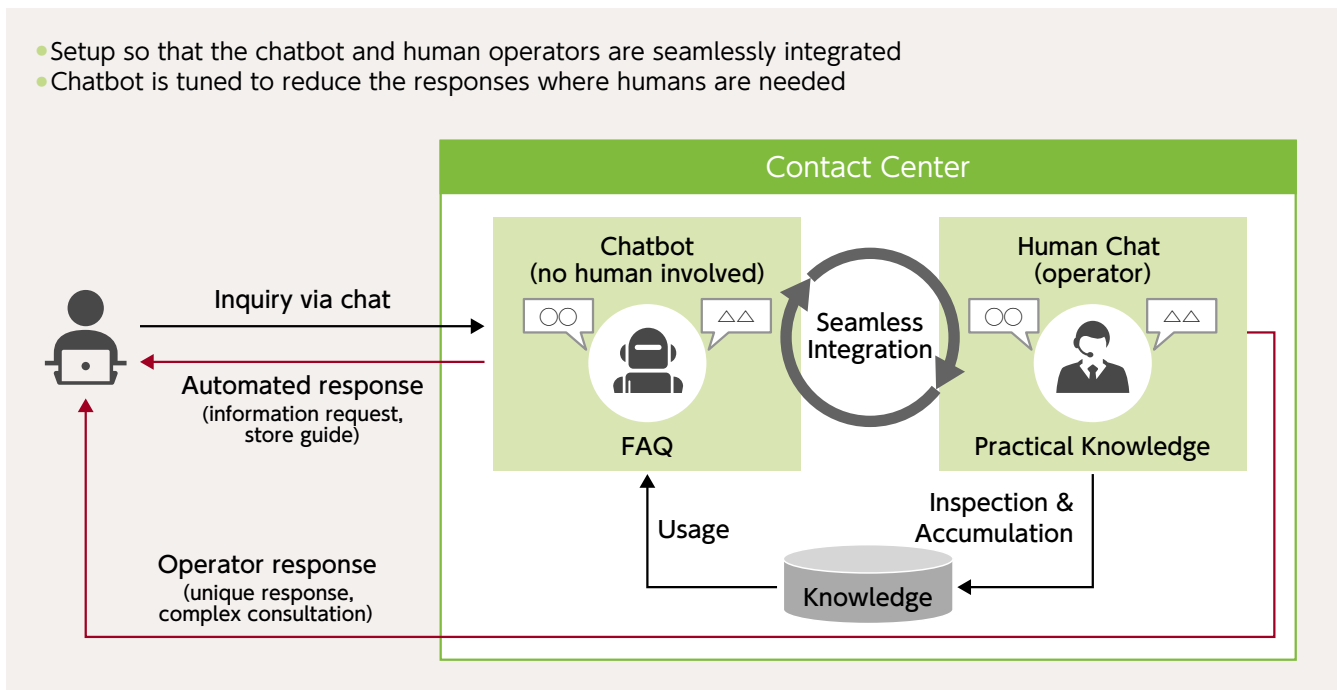


Fig. 2: Since there are limits to current chatbots, human responses are necessary

complaints or claims. Veteran operators can assess these situations with exquisite technique and even turn negative experiences into a positive outcome. This is the genuine realization of customer engagement. Current chatbots are not up to this task, and they should not be allowed to oversee complaint handling. This was considered when CHORDSHIP was being designed (Fig. 2).

While this may seem obvious, responses to routine questions should be left to chatbots, and human operators need to be allowed to devote themselves to inquiries that require a sophisticated response. Alternatively, up front an answer can automatically be provided by a chatbot, but in the event things that cannot be answered or a more detailed answer is asked for a function to escalate the inquiry to a human operator is important.

Although this is a bit of a tangent, a problem commonly heard at contact centers operated by people is that they cannot manage Voice of Customer (VoC) analysis. Since speech recognition is not yet practical, correspondence history is typically input by operators. The result is that users' voices are not directly stored, and it is difficult

to develop a correspondence history that is worth analyzing.

In the sense of improving this, it is also important to set up a means for a chatbot to conduct VoC analysis, as well as business processes. Dialogue using a chatbot can be stored as data, so trends as to how often certain content is accessed, statistical information as to which classifications had high numbers of inquiries, and what responses were and were not useful can be analyzed, along with verifying content. By analyzing what kind of inquiries are common or in what situations the involvement of a human operator was called upon, product manuals and websites can be improved, in addition to adding sophistication to contact centers. Incidentally, CHORDSHIP has a dashboard function for VoC analysis.

Future Development of CHORDSHIP

We have looked at why it is important for responses to users to be handled by a hybrid of chatbots and people. However, this story is of course not yet over. Rather, we will incorporate the results of the DL, and from

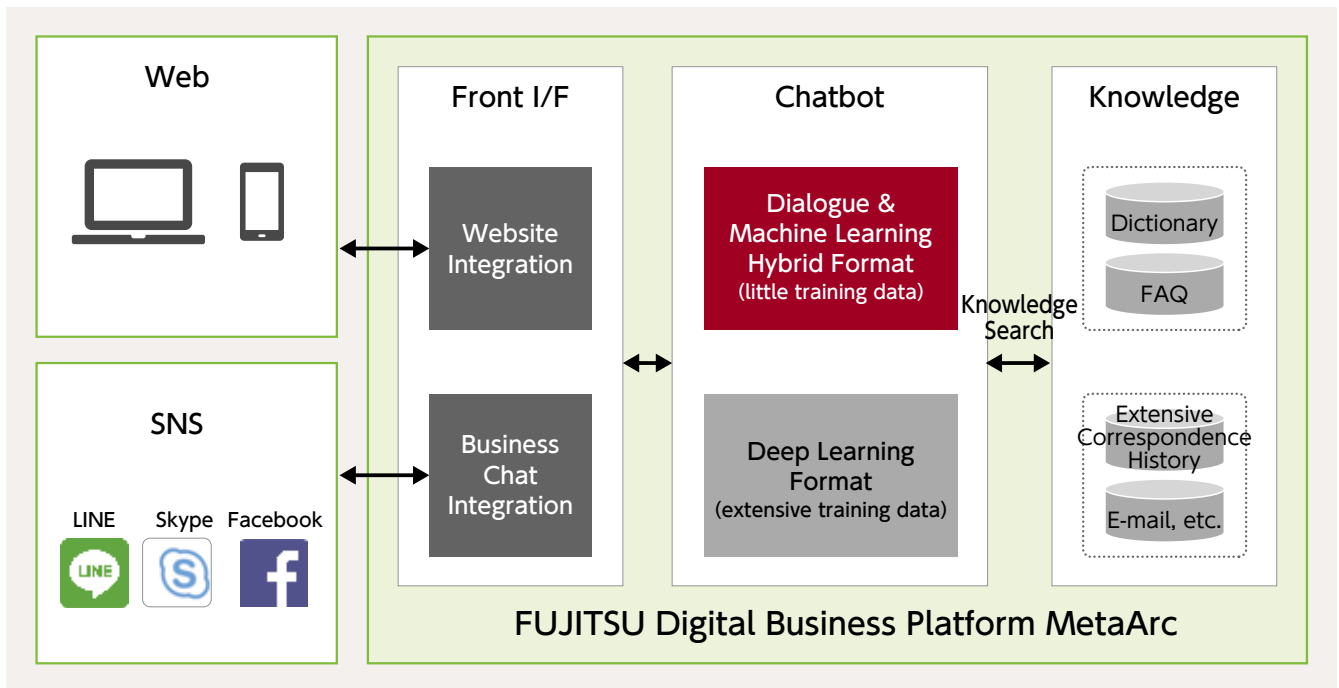


Fig. 3: CHORDSHIP's structure can be expanded as needed

there plan to evolve our chatbots (**Fig. 3**). Depending on the role of the contact center, sometimes it is best to be able to have small talk, and sometimes satisfaction is improved when a customer can chat using their voice. There is likely to be an increase in the necessity for image recognition corresponding to images from smartphone cameras. For that purpose, an API provided through "Zinrai" using Fujitsu's DL is already being implemented for tasks like trying to respond using image recognition and emotion recognition.

However, even if such functionality is added, for the time being at least, a hybrid system of chatbots and people is indispensable. It would be difficult to completely replace existing systems entirely with chatbots. It is difficult using AI technologies, including DL, to implement the sort of common sense that people have, so barring any major breakthroughs, we cannot hope for flexible responses.

Wireless Technology Spreading in Response to Needs and the Steady Evolution of Edge Computing

Tatsuzo Osawa Head of IoT Business Division, Network Services Business Unit

Out of the various digital technologies, the Internet of Things should be given top priority. Everything from equipment and tools at manufacturing sites, to machines and vehicles, to buildings and facilities, to people and their work, are becoming connected to the internet. This has an impact that affects all industries, including manufacturing, insurance, finance, transportation, agriculture, and so on.

At Fujitsu, IoT is regarded as the most important technology for technological development, strengthening personnel, and expanding our services, and in last year's edition of this collection of articles, the importance of focusing on sensors and IoT platforms has been explained (<http://www.fujitsu.com/jp/services/knowledge-integration/insights/iot20170705/>). Today, in this article I will explain how wireless technology is an indispensable element in tackling IoT and the internal structure of IoT platform.

Recognizing the Trends in IoT Wireless Technology

Wireless technology is imperative to IoT, as it makes it easier to install sensors and devices that need no wiring. However, there are some constraints as to device power consumption and radio frequency distribution. For example, if additional information such as error correction is added at the time of data transmission or greater distance for wireless communication becomes possible, to that extent, the effective rate of transmission decreases. Although wireless devices that run for years on only batteries are feasible, again communication time and potential distance are limited. For now, wireless technology that can satisfy all these conditions of communication speed, communication distance, power consumption, etc. does not exist in principle. Therefore, it is necessary to selectively use different wireless technologies based on the application.

← LPWA →

	Wi-Fi	Bluetooth (+Mesh)	Wi-SUN	SIGFOX	LoRaWAN	LTE-M (Cat.M1)	NB-IoT (Cat.NB1)
Frequency Band	2.4GHz/5GHz/920MHz	2.4GHz	920MHz	920MHz	920MHz	LTE/5G band	GSM/LTE/5G band
Speed	From ~100k to several Gbps	Several Mbps	~100kbps	~100bps	~10kbps	~1Mbps	~10kbps
Communication Distance	Tens of meters to 1km	Several 100 meters	1km increments	10km increments	10km increments	10km increments	10km increments
Network Topology	Star, Tree	Star, Tree, Mesh	Star, Tree, Mesh	Star	Star	Star	Star
License	Unneeded	Unneeded	Unneeded	Unneeded	Unneeded	Needed	Needed
Station Setup	Available	Available, usable by smart devices	Available	Unavailable	Available	Unavailable	Unavailable
Population Coverage Rate of Service	Only specific spots	No service	No service	99% (by 2020)	Only specific spots	Over 99% (future)	Over 99% (future)
High-speed Movement	Unavailable	Unavailable	Unavailable	Unavailable	Unavailable	Available	Unavailable
Power Consumption	Low	Extremely low	Low	Extremely low	Extremely low	Low	Extremely low
Usage Example	Sharing collected relay of IoT devices with smart devices	Wearable sensors, home-use	Smart meters, industrial sensors, home-use	Smart meters, observation	Smart meters, self-supporting equipment monitoring	Moving bodies, video-use	Smart meters, observation, equipment monitoring

Table 1: Representative IoT Wireless Technologies

However, the typically jumbled field of communication technologies has progressed in terms of standardization, and technology with lower power consumption (low power) and great effective communication distance (wide area) or LPWA (low power wide area) has spread. The number of telecommunications carriers, etc. providing wide-area wireless communication services making use of this technology has increased, and choices are increasing. To that extent, the number of things needed to know has also increased. Indeed, even just the representative number of wireless technologies that work with IoT are numerous (**Table 1**).

Here we will look at the frequency band and topology as shown in Table 1. In the frequency band, there are those that can be used without license under set conditions, such as 2.4GHz/5GHz/920MHz, and there are those that require a license provided by a mobile carrier, such as GSM/LTE/5G bands. Development has been especially remarkable in relation to short range wireless technologies and products that can be used without a licensed band. In general, the higher the frequency of the band, the larger the distribution of the frequency, which results in improved communication speed. However, as the attenuation of the radio waves increases, the distance it can transmit shortens, so the straightness of the radio waves becomes stronger, and it becomes difficult for radio waves to reach their destination indoors, in shade, etc.

Network topology is the form connection takes between wireless devices. The basic form of only one stage of connection is called a star. Putting multiple wireless devices together to increase total wireless communication distance is a tree. Additionally, when a wireless relay device fails within the tree, a mesh can be utilized to allow for detours to provide uninterrupted communication.

LPWA Services Continue to Grow

Next, let's look at the communication technologies in Table 1. Wi-Fi and Bluetooth are technologies used on both PCs and smart devices. Wi-Fi includes industrial technologies

that use the 920MHz band (strictly classified as LPWA), and mesh feature standardization for Bluetooth has been completed in 2017 and which continues to evolve. Wi-SUN has also become standardized as a mesh network technology for industries. It has been adopted for road lighting, parking lot systems, smart meters for power networks, and the like.

The four on the right are generally classified as LPWA. Of these, SIGFOX is currently being utilized predominantly by emerging French telecommunications carriers. Kyocera Communication Systems launched its service in 2017 in Japan. LoRaWAN is the only option for LPWA that can be installed as a self-service station without a license, and various demonstrative experiments for both large and small are being conducted in Japan. LTE-M and NB-IoT, LTE and 5G are IoT communication services provided by cellular carriers, and as of January 2018, Japan's first LTE-M service will start at KDDI with each communications carrier contributing thereafter.

So when incorporating IoT, how are these technologies best used? Even though making a comparative exploration referring to examples applications of each technology indicated in Table 1 is fundamental, but there are other alternative approaches. The wireless technology equipped on devices such as wireless sensors, etc. needs to be checked. For example, the majority of wearable devices use Bluetooth. In order to sense workers' vitals, being able to link to smartphones, etc. via Bluetooth is practical. Even when developing a new wearable sensor, it is assumed it will use Bluetooth. Of course, as development progresses there is always a chance that LPWA technology will be used, and we need to keep a close eye on that.

Characteristics of Wireless IoT Technology

Regardless of being official or actual, standardized IoT wireless technology is increasing, and new technology is also appearing in a progressive form. Standardization of IT technology like Wi-Fi is progressing, and following

that is commercialization and diffusion, so that IoT-type wireless technology is prioritized among the market, followed by standardization. Since these technological advancements are so rapidly, it is necessary to position useful ones for utilization. Would like to introduce a few for reference.

Sony's LPWA works reliably at high speeds over exceptional distances of over 100km, and is technologically enables to communicate under low power consumption. The tradeoff is that the effective speed is ultra-low at 80bps.

By selecting the most optimized transmission system and error correction technology, these specifications were realized. (However if) Environment where transmissions brought from mobile carriers which are hard to reach such as mountains, oceans, etc., and an environment where self-supporting station is difficult to build, this new method of connection will be provided.

On the other hand, Fujitsu has developed an ad hoc wireless system, as its mobile unit functions as a relay device. Even if the topology changes when a person walks and the location of the mobile unit moves, transmission will remain stable (**Fig 1**). Relay devices had to be fixed under the conventional technology. However, this technology will be able to utilize under an environment where relay device cannot be fixed, such as temporary work sites, etc.

Even though the needs for the wireless technology is underdeveloped, there is a possibility that it may have been developed and also possible to develop new technologies as well. Tradeoff will remain existed with regards to distance and speed, however, there is a technology that will always achieve the objective. These are the interesting part of the IoT wireless technology.

Basic Configuration of IoT Systems

There could be an impression that IoT systems consist of sensor devices, wireless technology, and applications

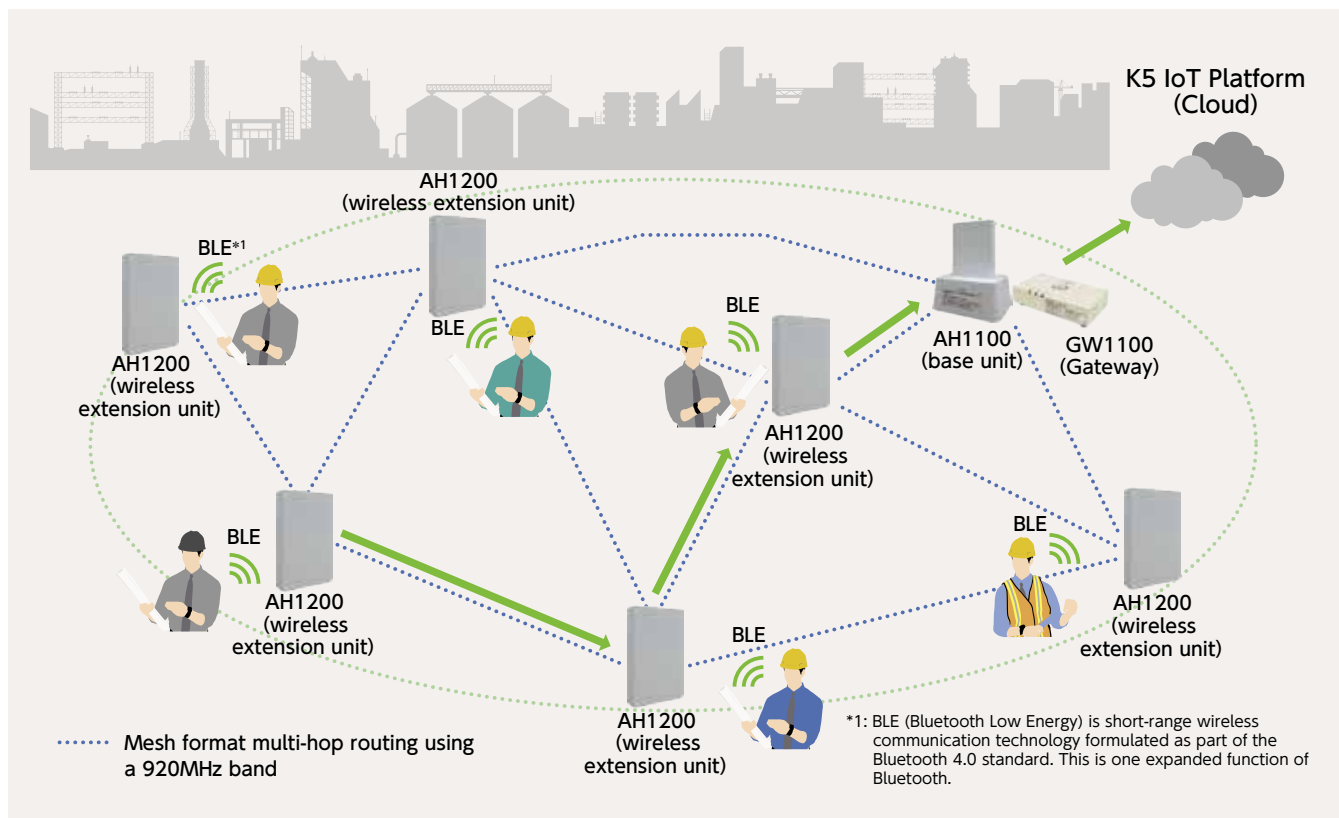


Fig. 1: Fujitsu's Ad Hoc Wireless System for IoT "FUJITSU Network Edgiot Series" (<http://jp.fujitsu.com/solutions/business-technology/iot/product/edgiot/>)

using the cloud. Sensor information can be appropriately collected and handled while monitoring, and the sensor can be directed if necessary. While this is true, actually many IoT systems adopt the basic configuration shown in **Fig. 2**. This is because unlike typical client server systems and web systems, some kind of flexibility is required.

One ingredient of IoT systems is the "edge server", which is not initially unheard in the corporate information system. If a great deal of data sent by sensor devices is being processed on the cloud side, the processing load of network bandwidth naturally becomes significant on the application side. That is when the edge server becomes necessary for processing. Only the necessary data is introduced by the broker and sent to the application. Although this is not seen much at the moment, this has a role similar to department servers in enterprise systems.

By setting up edge servers, there is also an advantage that comes from combining short-range network

technology and wide-area network technology. While this could be called a necessity, some things such as Bluetooth enabled sensors cannot be connected to the cloud by themselves. If using a smartphone or PC as an edge server, it can connect to cloud technology using a mobile communication network. This pattern is often applied to vital sensors, etc. that actively monitor the physical condition of workers. Aside from security and reliability, responses, etc. are also notably effective. This form of processing is called "edge computing," and various technological advancements are being developed.

In many cases, a "security gateway" that is responsible for security functions, such as encryption and authentication, is installed. In addition to IoT sensor devices that operate on their own, the number of devices deployed and used becomes quite large. Therefore, a typical two-step authentication method such as a human system authentication method cannot be applied. In place of that, authentication using digital certificates can provide reliable security.

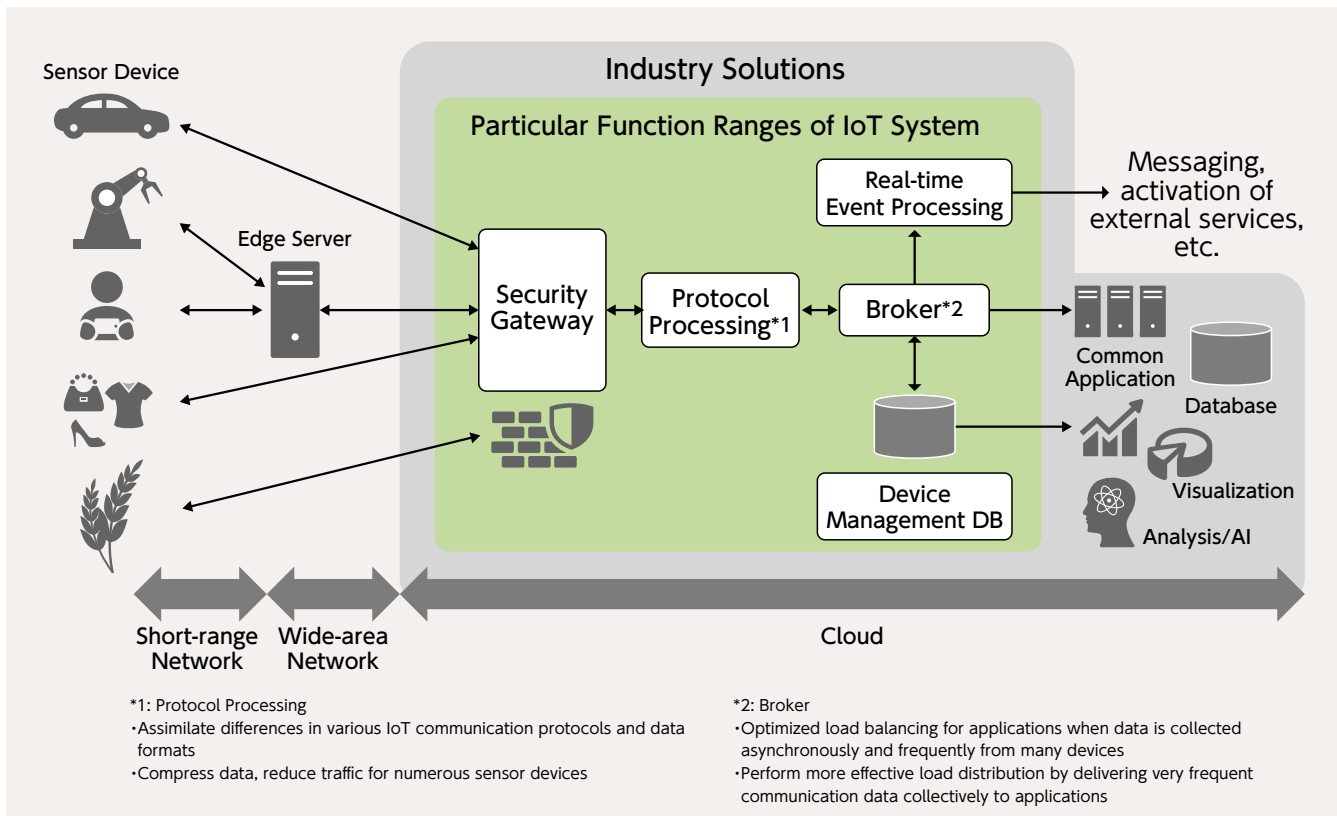


Fig. 2: IoT System Basic Configuration

There is also "protocol processing" that assimilates the differences among the various communication protocols of IoT and data formats. Once the IoT system has been built, it is not at all uncommon to add new types of sensors, and the flexibility of protocol processing has an influence on scalability. Additionally, if data compression and decompression is processed here, communication volume can also be saved.

"Broker" is a general technical term not exclusive to IoT. As the name suggests, it plays a role in mediating between devices and applications, and appears generally in all messaging systems, including personal communication systems like chats and bulletin board systems. The role it plays is to appropriately off-load the application's load while asynchronously and frequently collecting data from many devices. This is the same as the role of load distribution in a web system, but it does not set standard loads when balancing, making it capable of responding to the unique requirements of IoT.

For example, going beyond just gathering data, it can also respond to instructions issued in communications, support multiple communication protocols, off-load to the application more effectively by grouping together exceptionally frequent communication data, and so on.

"Real-time event processing" assesses the contents of delivered data, and can notify an administrator via e-mail if necessary and call external services. The "device management DB" manages the status of sensor devices and edge servers, confirming their operating

status and changing operational parameters, as well as being responsible for software updates for sensor devices and edge servers.

Effectively Utilizing IoT Platforms

The implementation of the functional elements of an IoT system already discussed constitute what is called an IoT platform. Although the composition varies somewhat based on the provider, cloud services such as AWS IoT Core, Azure IoT Hub, and IoT Platform (NTT Communications), etc. are provided. Naturally, Fujitsu also offers the K5 IoT Platform.

Still, in certain industries numerous IoT solutions appearing, including databases and interfaces that integrate the use of sensor devices, as well as analysis and visualization applications, etc. By putting together databases, analysis, and AI optimized for the manufacturing and each distribution industries, etc., there is no need to combine and implement general-purpose products, and you can use an IoT system which can be used at ease.

Examples at Fujitsu include COLMINA for the manufacturing industry, SMAVIA for the distribution industry, and Akisai for agriculture. Moving forward, by utilizing the data accumulated from these platforms and solutions across various industries to assess solutions that transcend the boundaries of existing industries are expected to be considered.

Japanese Companies Recognizing the Impact of "NIST SP800-171"

Taishu Ota Evangelist, Cyber Security Business Unit

Because there is a security related guideline which is well not known but cannot be overlooked that will highly possible to impact many companies. For companies developing and manufacturing products and technologies supplied by U.S. government agencies, these are called "NIST SP800-171" (Fig. 1).

If in light of the guidelines there are deficiencies, there is a possibility that the supplier will be excluded from the vendor list. The Department of Defense (DoD) already seeks compliance from those engaged in business exchanges, and Japanese defense firms that are suppliers for the DoD cannot neglect them. Under the circumstance, it may impact companies even though it do not involve in defense firms.

Today, IT is a component of machinery, vehicles, electronic devices, and numerous other services and products. That holds true without even mentioning IoT, which is frequently used to connect to other external devices and services. For the wide variety of information tied up in these products that use IT, NIST SP800-171 lays out a proper management method. At the moment, it may be targeted at products made use of by government agencies, but there is a likelihood it will spread to private companies.

In addition, there is a high probability that rules originating in the U.S. will affect countries around the world, including Japan, and standardization based on the level of NIST SP800-171 will possibly move forward in various countries and industries. In an extreme case, we

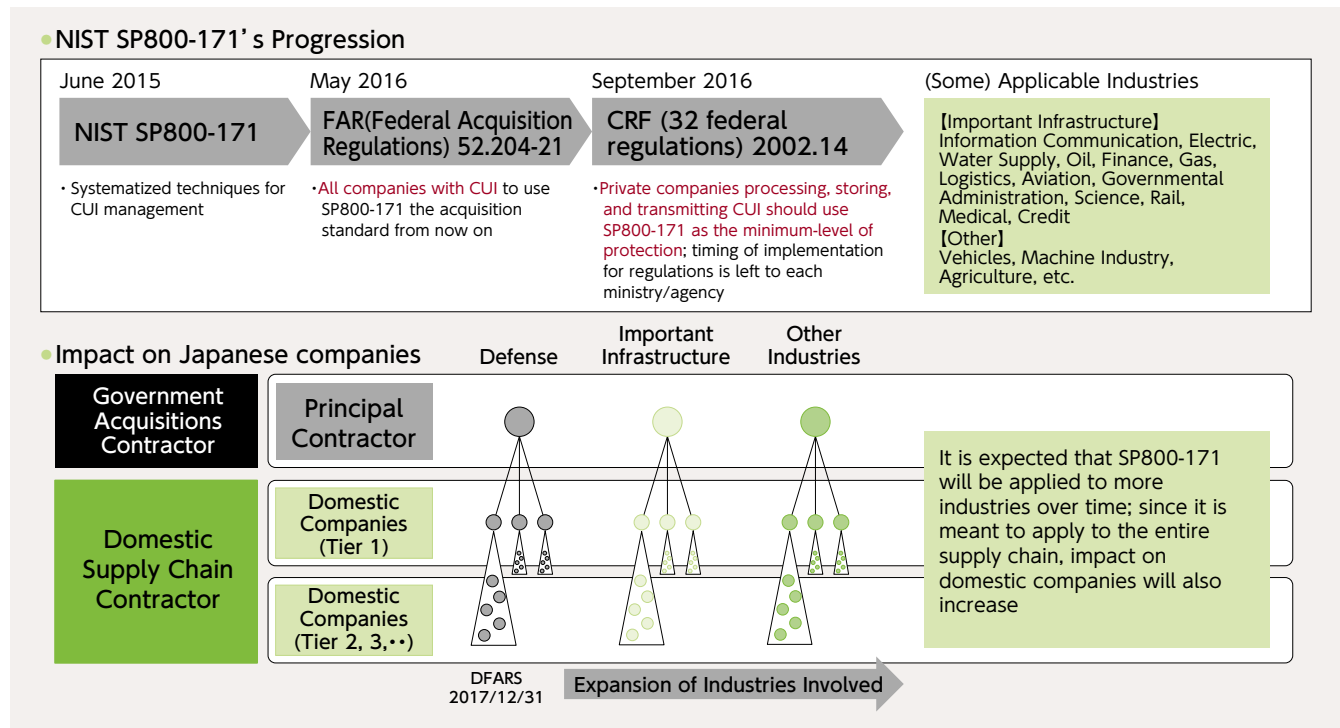


Fig. 1: NIST SP800-171's Progression and Impact on Japanese Companies

should consider that companies that provide products or services that incorporate IT or rely on IT will be required to comply with these guidelines (or something similar).

Therefore, we will focus on NIST SP800-171 in this section, and consider the impact on the business of Japanese companies. Needless to say, Fujitsu does not focus solely on NIST SP800-171, and watches the security policies of each country to stay one step ahead in our thinking of how to provide services and know-how that contributes to companies (Table 1).

Understanding Key Points of NIST SP800-171

First, let us look at the context that NIST SP800-171

was formulated in. Today, vehicles and electrical devices have IT (computers) built in almost without exception. While it is natural that attention is given to security during development and manufacturing; nothing is perfect. For example, in 2013, it became clear that Fiat Chrysler cars could be remotely controlled via hacking, and in 2015, the company had to recall 1.4 million vehicles.

On a related note, what would be the result of someone with malicious intent remotely controlling equipment and electronics used by the U.S. government through hacking? Even without stating what would happen explicitly, it seems more than a little obvious that such an outcome needs to be headed off at the pass. This is where NIST SP800-171 comes in.

Standard	Main Country	Content	Target	Regulations & Risks
ISO27001	International Standard	Information security management system	Business groups & service providers	Lack of tendering, etc.
PCI DSS	USA	Protection for cardholder information	Business groups & service providers	Lack of tendering, etc.
NIST SP800-171	USA	Protection of CUI in systems and organizations outside the federal government	Business groups & service providers	Lack of tendering, etc.
FedRAMP	USA	Security standards for procurement of cloud services	Cloud companies	Lack of tendering, etc.
HIPAA	USA	Medical information (requirements for the use, disclosure, and protection of personally identifiable medical information)	The legal entity with access rights to the protected health information (PHI), as well as business agents such as cloud service companies and IT providers, etc. that can process PHI	Fine of \$100 per human rights violation, Annual upper limit: \$1.5 million per type of violation
GDPR	Europe	Concerning the handling of personal information	Business groups & service providers	€20 million, or 4% of worldwide sales for the previous year, whichever is higher
NIS Directive	Europe	Introducing latest security measures for important infrastructure-related businesses, complies with international standards for technical levels	Business groups & service providers	Depends on the country
C5	GER	Security standards for cloud service providers	Cloud companies	Lack of tendering, etc.
KATAKRI	FIN	National security inspection standards	Business groups & service providers, data centers	Lack of tendering, etc.
Revised Personal Information Protection Act	JPN	Concerning the handling of personal information	Business groups & service providers	In cases of violating national decree, up to 6 months in prison and in cases of a false report of less than ¥300,000, a fine of up to ¥300,000 In cases of provision or stealing of personal information from a database for the purpose of unfair benefit, penalty of up to 1 year in prison and a fine of ¥500,000 or less
PDPA-2012	SGP	Concerning the handling of personal information	Individuals as well as companies, organizations, and groups (incorporated or not)	For companies or organizations in violation, fines of up to S\$1 million For individuals, in addition to fines, up to 3 years in prison
Cyber Security Law	CHN	Owners and administrators of networks and network service providers	Concerning the handling of personal information Concerning the obligations of companies involved with important information infrastructure	-Violation of protecting personal information: Confiscation of illegal earnings, and a civil fine of 1 to 10 times that of said earnings In the absence of illegal earnings, civil fine of up to CN¥1 million -Violation of obligations of important information infrastructure-related company: Civil fine of CN¥100,000 to CN¥1 million For operators directly responsible, a civil fine of CN¥10,000 to CN¥100,000

Table 1: Laws, Standards, and Directives Related to Cyber Security

NIST is the National Institute of Standards and Technology, which is responsible for various U.S. technical standards; they abbreviate Special Publication as SP, and the 800 indicates that the report was issued by the Computer Security Division (CSD) within NIST. 171 is the designation for a report titled "Protecting Controlled Unclassified Information in Nonfederal Systems and Organizations."

The key point here is the "Controlled Unclassified Information (CUI)" part of the title. Classified Information (CI) is incidentally confidential information that requires very strict handling. Therefore, CUI refers to non-confidential (classified) information. For example, information such as product specifications, experimental data related to product development, etc. In NIST SP800-171, the matter of protecting CUI is addressed as an important issue. This is because the unintended publication or leakage of CUI can have effects on security and the economy. But just what is "protecting controlled unclassified information?"

CUI Leakage and Likely Problems

Let us consider a system related to some important infrastructure as an example. Even though the companies responsible for working on this system may handle the classified design documents carefully, there is a possibility that the specification forms, etc. will not be managed as strictly. If a third party with malicious intent were to obtain such specifications due to this lax management, what could happen?

The system's vulnerabilities can be determined based on information garnered from the specifications, and there is an undeniable possibility that the important infrastructure will be shut down in the case of a cyberattack.

This is the reason why protecting CUI is important. In the U.S. in 2010, in accordance with executive order 13556, each ministry and agency has information that falls under CUI defined, and a CUI registry is managed by NARA (National Archives and Records Administration). Therein, CUI is defined for various categories such as important infrastructure, privacy, transport, geospatial information, etc.

Naturally, the CUI in the registry is highly diverse. Information that is considered CUI includes in addition to information on building materials and air conditioning equipment that goes into constructing a nuclear facility, information on the systems of water supply facilities, and information on government buildings, trial data related to self-driving vehicles, and design drawings and specifications for machine-made products, etc. Japanese companies that are involved somewhere along the supply chain of items delivered to U.S. government agencies are certain to have multiple sets of CUI in place, and component manufacturers situated upstream on the supply chain, whether there is awareness of it or not, do as well.

NIST SP800-171 issued security guidelines to protect such CUI in June 2015, and in FAR (Federal Acquisition Regulations) issued in May 2016, it was clearly stated that NIST SP800-171 is the standard for acquisitions for all industries dealing with CUI. Then, in September 2016, CFR (32 regulations) 2002.14 was issued, and the application period was left up to each industry. In other words, the period for these to go into effect differs by industry, but industries with CUI and companies are required to comply with NIST SP800-171.

They have already been applied to the defense industry. The DoD issued DFARS 252.204-7012 in October 2016, establishing that "DoD contractors will comply with NIST SP800-171 by December 31st, 2017." Of course, this required compliance goes beyond just the principal contractor and includes all supply chain companies, including related Japanese companies. From this point forward, when similar mandates are given for other industries to have protection based on NIST SP800-171, there is a high probability that many Japanese companies will be affected, beyond the realm of the defense industry.

The Requirements of NIST SP800-171 Are Not Unusual

So what measures are companies required to take under NIST SP800-171? As a basis, there is the "CSF (Cyber Security Framework)" issued by NIST to

protect important infrastructure. The CSF consists of 5 functions: "identify," "protect," "detect," "respond," and "recover." This picture can be similarly applied to the requirements of NIST SP800-171 (**Table 2**).

Please, take a look at the right side of Table 2. The family of NIST SP800-171 requirements (3.1 to 3.14) details 110 items. There are 77 technical requirements and 33 non-technical requirements. The technical requirements include items pertaining to access control, configuration management, authentication, encryption, system monitoring, detection and defense against malicious code, etc.

As for non-technical requirements, the points are divided more broadly into elements of risk assessment, system management, and also an obligation to make a prompt report to authorities when an incident is detected (when related to the DoD, this must be done within 72 hours), etc. For example, when it comes to risk assessment, the organization's information assets, including CUI, are identified, and the impact of unexpected disclosure, destruction, or amendments, etc. to those assets is evaluated. In addition, the vulnerability of information systems is evaluated, and improvements to them are required. As far as system management is concerned, in addition to improving the security awareness and training of information system administrators, system

administrators, and users, there are requirements set pertaining to auditing and accountability, etc.

Moreover, in order to respond promptly when an incident occurs, the timely sharing of information with concerned parties and implementation of incident response tests connected to organizational planning (BCP, etc.) are required. The necessity of reporting promptly to concerned authorities when an incident occurs, as far as stipulated, can be said to be an extremely courteous guideline.

Further, each of these items building to the establishment, maintenance, and skilled operation of a security system is a natural requirement, and is not an unusual guideline. However, there is certainly reasonable effort required to comply with the guidelines in a form that ensures accountability.

Incidentally, there is no problem with self-declaring compliance with these requirements, and proof via external third party examination is unnecessary. However, if a suitable explanation cannot be given when asked for by procurers and clients, contracts may be cancelled, and in the case of a violation, care must be taken with the accompanying risks that there may be a breach of contract.

NIST CSF (Cyber Security Framework)			NIST SP800-171	
Before Attack's Intrusion	Identify	Deepen understand necessary for managing systems, assets, data, and known cyber security risks	Technical Requirements / 77 Items	
	Protect	Consider and implement appropriate protection measures to ensure the provision of important infrastructure services	3.1 Access Control / 22 Items 3.4 Configuration Management / 9 Items 3.5 Identification & Authentication / 11 Items 3.7 Maintenance / 6 Items 3.10 Physical & Environmental Protection / 6 Items 3.13 System & Communications Protection / 16 Items 3.14 System & Information Integrity / 7 Items	
After Attack's Intrusion	Detect	Consider and implement appropriate measures to detect the occurrence of cyber security events	Non-technical Requirements / 33 Items	
	Respond	Consider and implement appropriate countermeasures to handle detected cyber security events	3.2 Awareness & Training / 3 Items 3.3 Audit & Accountability / 9 Items 3.6 Incident Response / 3 Items 3.8 Media Protection / 9 Items 3.9 Personnel Security / 2 Items 3.11 Risk Assessment / 3 Items 3.12 Security Assessment / 4 Items	
	Recover	Formulate and maintain plans to allow for resilience, and consider and implement measures to restore all functionality and services when they are obstructed by a cyber security event		

Table 2: NIST CSF/NIST SP800-171 Security Requirements

Using SOC for Compliance and Recommending Cloud Tech for CUI Management

Finally, I would like to briefly discuss the direction for companies to take in complying with NIST SP800-171. The fundamentals of NIST SP800-171 come from the ideas of defense in depth based on the concept of CSF. Compared with the international standards for security in the "ISO 27000 Series", a major characteristic is that they focus on countermeasures that take effect after a cyberattack has caused a breach of security.

To put it another way, the ISO 27000 Series emphasizes defending against cyberattacks through countermeasures such as defense in depth targeted at external connections and end points. In contrast, CSF uses defense in depth and encryption of internal communications based on the premise that an attack has already breached the system, and essentially, focuses on how to minimize the impact of such attacks.

From this perspective, NIST SP800-171 asks companies to minimize damage through rapid incident response and gathering information on unknown threats. Personnel resources with expert knowledge are necessary to conduct analysis when an incident occurs and to make proper judgements. The same is true of organizations that gather information.

This kind of system needs to run 24 hours a day, 365 days a year, and also needs to maintain the whole supply chain, including small and medium-sized businesses; this does not happen overnight. In addition, when reworking and rebuilding a system to reach the level where it is in compliance with NIST SP800-171, a considerable investment is necessary, and when NIST SP800-171 is revised, making further adjustments will cost more. That is why this is an initiative that needs to be undertaken as early as possible (**Table 3**).

Still, solutions and cloud services to alleviate some of this burden have also come out, for example third party Security Operation Centers and secure cloud services. Personally, I think that adoption of these services and using a cloud system to handle CUI is the real solution. Of course, not all clouds are the same quality, and the U.S. government's FedRAMP (The Federal Risk and Authorization Management Program) certification is essential to cloud procurement; you could say that it is a prerequisite. Even in that ideal case, it is necessary to establish appropriate access authentication, management of access permissions, encryption of communications, an ability to be used with applications, and recovery methods, etc. Therefore, I would recommend that you look the situation with your company as soon as is possible, and I also would like to recommend considering countermeasures.

	STEP	Overview
Assessment	STEP1 Corresponding CUI Analysis	Analyze what company business involves information considered CUI in U.S.
	STEP2 Identifying Range of Present CUI	Identify range of CUI currently possessed
	STEP3 Analysis of Present System Status	For systems with CUI, perform a current status analysis based on NIST CSF
	STEP4 Analysis of Compliance Rate	Perform Fit Gap analysis with NIST SP800-171 technical requirements
Implementation	STEP5 Fundamental Planning	Create a basic plan for how to act in relation to NIST SP800-171
	STEP6 Detailed Planning	Design a more detailed plan based on the basic plan
	STEP7 Hardware Implementation	Implement hardware required to comply with NIST SP800-171
	STEP8 Create Operational Rules, Document Maintenance	Create operational rules for an environment compatible with what has been constructed for NIST SP800-171, and improve and implement documentation that clarifies the locations of responsibilities, etc.

Table 3: How to proceed with NIST SP800-171; it is recommended to start assessment as early as possible

In the World of R&D Advancements in Next-gen Computing, What is the Potential of Combinatorial Optimization Using Annealing?

Hiroyuki Yoshida Principle Engineer, AI Service Business Unit

Computing performance doubles every 1.5 to 2 years. This is Moore's Law and it has been a guidepost for growth in computer performance, but as we begin to reach certain limits, making the same level of advancements at the same rate as before has become difficult. However, the amount and types of data needed to be processed are increasing by orders of magnitude, and the problems needing to be solved are becoming increasingly complicated. This has led to a greater interest in next-generation computing technologies, especially "quantum computers" that are based on principles of quantum mechanics.

But what really are they? 1 bit on an existing computer system can only be in a 0 or 1 state, but a Qbit on a quantum computer system does not have to be only a 0 or 1, as it can exist (be expressed) as two states. If used effectively, a quantum computer with n Qbits can calculate 2^n states in parallel; essentially, it can calculate both states simultaneously.

Increased Interest in Next-generation Computers

Prior to the 2000s, Japanese companies and universities were engaged in basic research, but in recent R&D into practical application, the efforts of U.S. companies such as IBM, Google, Microsoft, and Intel have become the forerunners. For instance, IBM has released the Cloud-based quantum computing platform "IBM Q". There is also a venture company called IonQ working on quantum computers that utilize ions.

However, the IBM Q system is still only 20 Qbits. IBM and Google will reach 50 Qbits, and within a few years

they will reach 100 Qbit level by 2018. While work is being done to reduce the costs for cryogenic cooling to maintain a quantum state and developing a system with the several thousand Qbits that are needed for error correction in a quantum computer; A few more years will be needed in order to reach practical usage.

The early commercialization of quantum computing came in 2011 via a Canadian startup called D-Wave Systems. Rather than the general-purpose "quantum gate" technology, they adopted "quantum annealing", and this drew attention when joint purchasers Google and NASA announced research results showing speeds "100 million times faster than a conventional system". After that, automotive-related enterprises and others began to use it, and progress is being made in its application.

So what is quantum annealing? To put it simply, it is a system specialized in solving "combinatorial optimization problems". Attention has been focused on combinatorial optimization problems, and using conventional digital circuit technology as a base, Hitachi and Fujitsu have been developing architecture suited to solving combinatorial optimization problems. Further, in collaboration with NTT and the National Institute of Informatics, Fujitsu is developing specialized machines based on nonlinear optics toward this same goal.

This sort of specialized computer architecture centered on a specific field (domain) is called "domain-oriented architecture", and it is the popular approach for pursuing greater computer performance as the limits of Moore's Law are reached. However, in the flow of developing general-purpose quantum computer systems, there is a trend toward research and development of domain-oriented

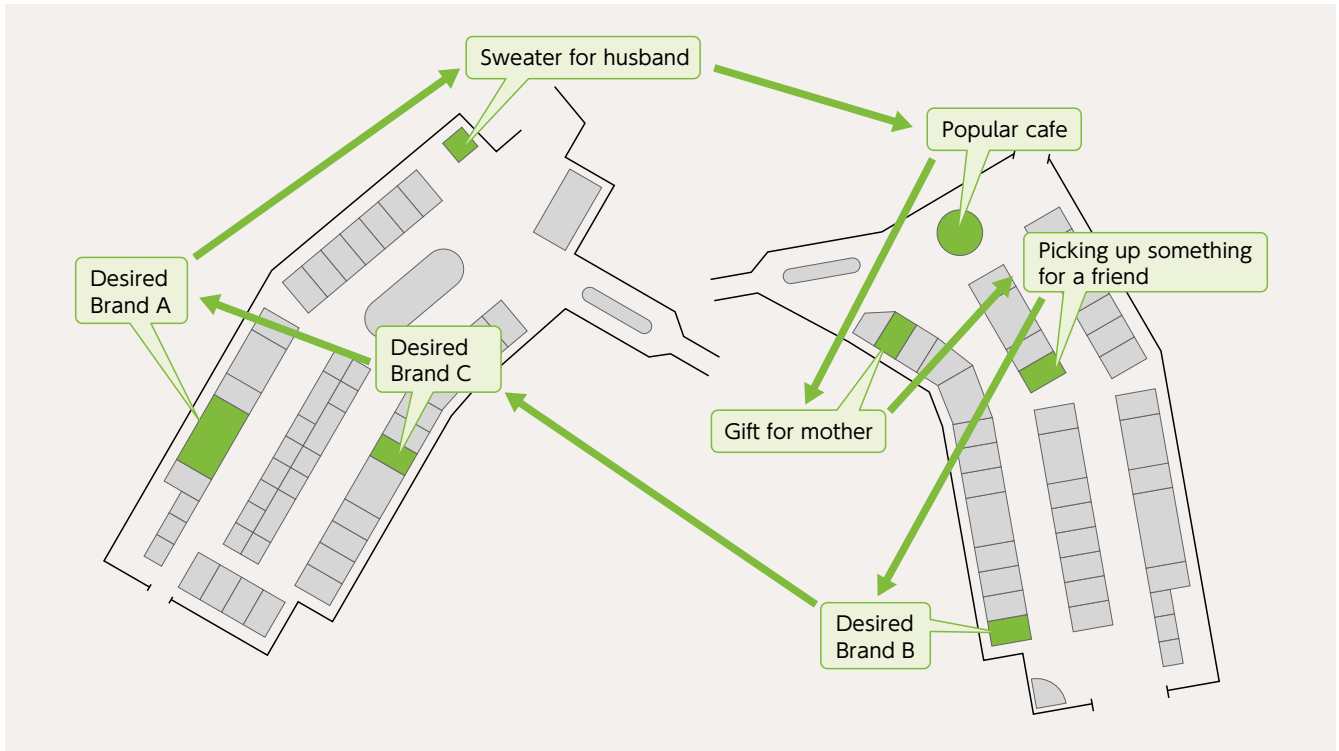


Fig. 1: Shopping Mall Route Problem

architecture to resolve presently existing problems.

In order to understand these trends in next-gen computer technologies, here we will discuss what combinatorial optimization problems are and how we solve them.

What are combinatorial optimization problems?

In our modern age, a large amount and variety of information has been digitalized and is readily available, and with this data as a foundation, it has become extremely important to be able to quickly pick out the optimal item from a great plurality of options. Often, there are several things that need to be determined, multiple selections need to be made based on each of those, and in some cases, decision making is necessary to optimize how they are combined. This is a typical "combinatorial optimization problem".

Though it may not be something heard of that often, there are actually numerous combinatorial optimization problems that exist in society and the industrial world. There are many themes/applications, such as optimizing traffic flow,

optimizing material procurement and production planning, optimizing the layout of production facilities, or machine learning requiring extensive calculations, etc.

Let us consider an example. Think of optimization of diversified investments in the 1st and 2nd sections of the Tokyo Stock Exchange, domestic emerging markets, domestic bonds, investment trusts, stocks in developed countries, bonds in developed countries, bonds in developing nations, etc. If there are 1,000 stocks in each category, then selecting 5 stocks from among them offers over 8 trillion potential combinations. If there are 7 categories, then that is 8 trillion to the 7th power or roughly 2×10^{90} . Of course, the actual number of combinations is irrelevant, the point that needs to be understood here is that finding an optimal solution in these situations involves handling a number of combinations that is simply enormous.

One common problem in the field of shipping and transportation is the "traveling salesman problem". As an everyday example, let us say I am going shopping at a shopping mall, and there are several shops I want to go to; however, there are a few conditions (**Fig. 1**). I want

to limit the amount of walking I do as much as possible. One of the things I am buying at a store is quite cumbersome, so I want to shop there last. I want to stop by Store A after going to Store C... Here the category of options is stores, and the choice of what order to visit the stores in is a combinatorial optimization problem.

If there are 7 stores you want to go to, then there are 5,040 potential routes. Although this seems like nothing serious, if you wanted to go to 20 stores for example, you end up with 2.4×10^{18} routes. If the optimum route can be selected when performing tasks such as delivery of goods to convenience store chains and parcels by delivery services, then it is possible to greatly reduce costs and CO2 emissions. This is how the number of combinations that needs to be examined increases exponentially as the number and variety of options increases, and that these problems are difficult to resolve in a reasonable timeframe on current computers is a distinguishing feature of combinatorial optimization problems.

What is the annealing method for solving combinatorial optimization problems?

In order to solve combinatorial optimization problems, a stochastic calculation method called "annealing" has been used. This is another term that you are unlikely to have heard often, but in metal refining

there is something called "annealing", and it refers to a phenomenon when metal heated to a high temperature is gradually cooled, altering the properties of the metal so the crystal lattice becomes softer and more ductile.

Annealing follows the principle of this process in trying to obtain optimal solutions to combinatorial optimization problems. For example, if I want to assume a 1,000 piece jigsaw puzzle so that it fits perfectly within a frame. Even if you take the puzzle in hand and try to make it fit, you can deduce easily that there will like be an enormous amount of trial and error (**Fig. 2**). However, using the annealing method, the puzzle pieces are arranged as you like, and then they are slowly stirred around until surprisingly they all fall into place!

Still, unlike the physical phenomenon involving metal crystals, in order to use annealing for combinatorial optimization, the problem needs to be mathematically expressed (formulated) as what is called an "Ising Model". Ising models are models to analyze how crystal lattices are formed in statistical mechanics. In the Ising model, the problem is expressed as a quadratic equation consisting of numerous variables, the weighted total sum is regarded as energy, and it tries to discover probabilistically the state that is stable with the lowest energy.

First, all the variables are randomly initialized in what

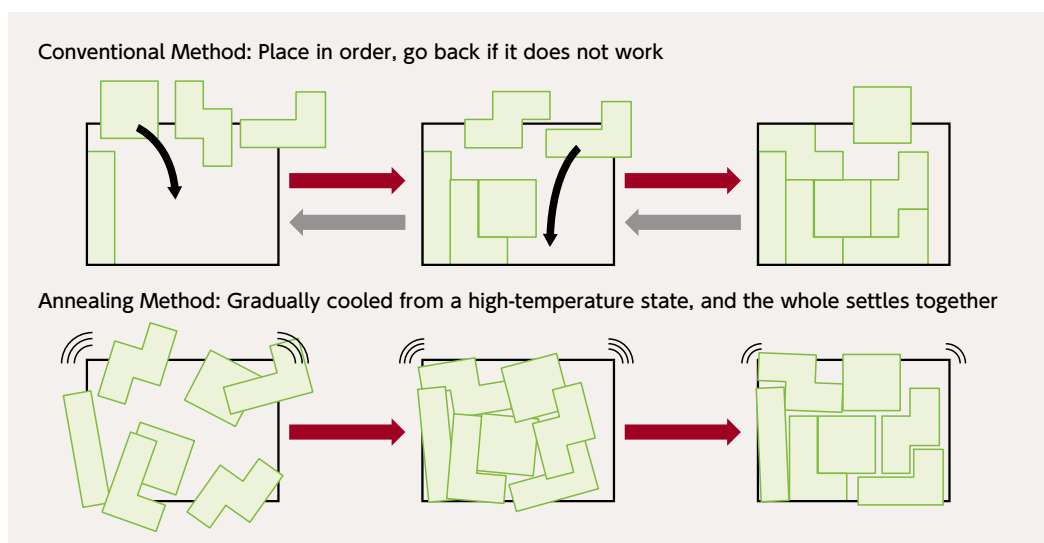


Fig. 2: Principle of Annealing

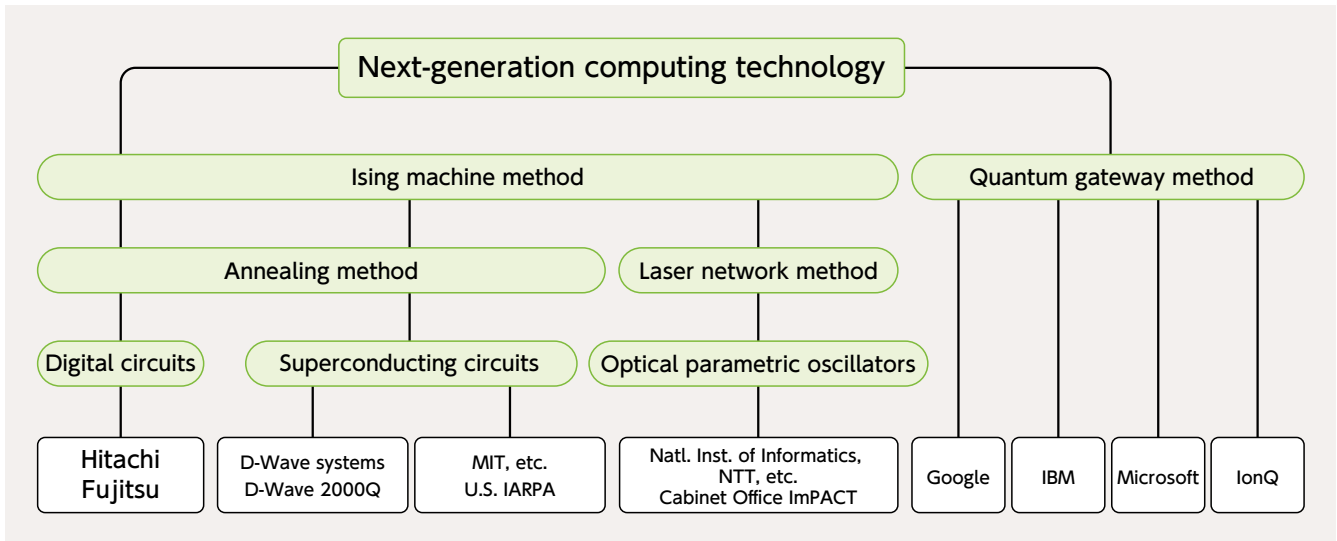


Fig. 3: Comparison of Each Method

can be considered the high-temperature state (a non-optimal state is set assigning variables randomly). In this state, each variable is randomly inverted, and a myriad of combinations are tried. Next, the degree of randomness is gradually reduced, and conversely, the degree of compliance with the constraint conditions is gradually increased. This corresponds to the gradual cooling of the metal in the physical phenomenon.

If the temperature is reduced sufficiently slowly enough, there is a high likelihood that the energy will eventually settle in the lowest state according to the constraints. Using this method, there is a probability of finding an optimal solution in a much more reasonable amount of time than compared with evaluating all possible combinations equally.

The Real Machines & Domain-oriented Architecture of Quantum Annealing

In 1998, Professor Hidetoshi Nishimori et al. of the Tokyo Institute of Technology proposed a method called "quantum annealing" to solve Ising models using quantum phenomena. Each variable of the Ising model is taken as a quantum, and at the start, is assumed to have a state of both 0 and 1. Then they are gradually divided into 0s and 1s, constraint conditions gradually come into effect, and finally, it is expected to settle on the optimal

combination. Professor Nishimori et al. reported that quantum annealing was more efficient than conventional annealing, and theoretically proved there was a high probability that it could find the optimal solution.

The aforementioned D-Wave Systems has made an actual quantum annealing machine, and the latest model has 2,000 Qbits. However, issues have been pointed out such as it being said there are missing bits from the yield problem, and since the number of couplings between the Qbits are few, there can be difficulties truncating the scale of problems to be solved during formulation.

Under these circumstances, R&D into "domain-oriented architecture" focused on combinatorial optimization problems is advancing in Japan (Fig. 3). In February 2015, Hitachi announced "we have developed a new type of semiconductor computer capable of high-speed processing of problems by simulating the expression of the Ising model on a semiconductor circuit". Fujitsu collaborated with the University of Toronto to devise a new computer architecture dedicated to annealing using conventional digital circuits, or a "digital annealer". In October 2016, it was confirmed that it was possible to solve the traveling salesman problem 12,000 times faster using a conventional CPU than through conventional annealing.

Following that, in November 2017, NTT, the National Institute of Informatics, the University of Tokyo Institute of Industrial Science, and the Japan Science and Technology Agency, among others, developed a machine specialized for combinatorial optimization problems called "QNN," and started offering it as a cloud service. The machine generates 2,048 optical parametric oscillator light pulses with quantum characteristics, and adopts a method that stabilizes to the optimum solution while making 1,000 laps of a 1km circular-long optical fiber cavity. Computers using domain-oriented architecture can be said to be moving ahead in practical application that is one-step ahead of quantum computers along the path.

Software is Important to Fujitsu's "Digital Annealer"

Lastly, let us talk about Fujitsu's digital annealer. The digital annealer is an architecture specialized for combinatorial optimization problems built on conventional digital circuits, and should a quantum computer be put to practical use that has the kind of exponential performance improvement we expect with respect to the number of Qbits, then it will be unnecessary.

However, a system with 12,000 times greater

performance over existing computers seems like a noteworthy advantage for the present. Cooling to induce quantum phenomena, as well as special installation space, is not required. Also, it is the node couplings/bindings and precision (value range of Qbit constraint condition equation = gradation) that impact overall usability. In the digital annealer, we think there is a well-balanced method where node couplings can all be combined and 65,536 gradations of precision also provide ease of use (Table 1).

However, with any method, including using the digital annealer, there remains the fact of one significant problem. Since this is all new architecture, only a few software exists. Fujitsu has partnered with leading quantum annealing software development company IQBit from Canada. In May 2018, we began offering a system that combines the digital annealer and IQBit's software as a cloud service.

Throughout the world various companies are understanding the tasks they have as combinatorial optimization problems, changing those combinatorial optimization problems to Ising models, etc., and developing these into programs and data that can be executed with a digital annealer... Developing quantum computers and specialized machines are themselves just devices to help the process, which is why software is so important.

		Fujitsu		Hitachi	D-Wave	NTT	Google	IBM	Microsoft
Method		Ising Machine Method		Ising Machine Method	Ising Machine Method	Ising Machine Method	Quantum Gateway Method		
		Annealing Method		Annealing Method	Annealing Method	Laser Network Method	—		
		Digital Circuits		Analog/digital circuits	Superconducting circuits	Optical Parametric Oscillators	Superconducting circuits		
Commercialization		2017	2018	2020	2011~	2018	Unknown	Practical use in 2020 to 21	Unknown
Latest Specs	Scale	1024bit	Enhancing plans	2048bit	2048bit	2048bit	(No simple comparison due to differing methods/systems)		
	Node Bonding*	Fully-bonded	Fully-bonded	Partial coupling	Partial coupling	Fully-bonded	(No simple comparison due to differing methods/systems)		
	Precision	65,536 gradations	Enhancing plans	128 gradations	16 to 32 gradations	3 gradations	(No simple comparison due to differing methods/systems)		
Stability	Operating Temp.	Normal		Normal	Ultra-low	Normal	Ultra-low (estimated)		
	Error Rate	Almost zero		Low (estimated)	High	Low	High (estimated)		

Table 1: Comparison of Each Technology

* If fully-bonded, conditions can be specified between 2 random variables, but if only partially bonded, placing of variables with conditions must be devised

OSS-driven Technology Trends involving Accelerating Service Development

Hiroyuki Kamezawa Senior Professional Engineer, Platform Software Business Unit, Linux Development Div.

Sun Tzu said that speed is the essence of war. "If you have the speed, you can strike while your enemies are unprepared". Whether or not this is precisely the same as in application development today, speed is very important. For externally-oriented services, those who are able to provide value before others gain superiority. In other cases, since speed provides room to try and try again, the application (service) can be refined.

However, even though there are engineers with exceptional programming ability, when it takes several months to plan and procure servers, speed is lost. To solve this problem, during the 2000s advancements were made in virtualization technology, and then, in cloud services (IaaS). The necessary IT resources can now be obtained in just a few minutes.

What came to have an even bigger impact than this was Open Source Software (OSS) (Fig. 1). Along with digitalization and servitization trends, major changes

continue to be made in how applications are developed. There is a strong indispensable force driving underneath to win the business.

That is why in this section, the transformation of technologies involved in application development over the past 10 years, focusing on OSS and including Microservices, etc. will be explained. It is decisively important for CDO, CIO or IT leaders to understand these movement in order to drive to the Digital Journey.

2006 and Now

In 2006, when the Amazon Web Services' (AWS) cloud service was released, an OSS called "Hadoop" for performing large-scale data distribution processing came on stage. There had been OSS -Linux and application servers, etc.- but they were costly to derive value from and were positioned as an alternative to commercial software. There was no product like Hadoop,

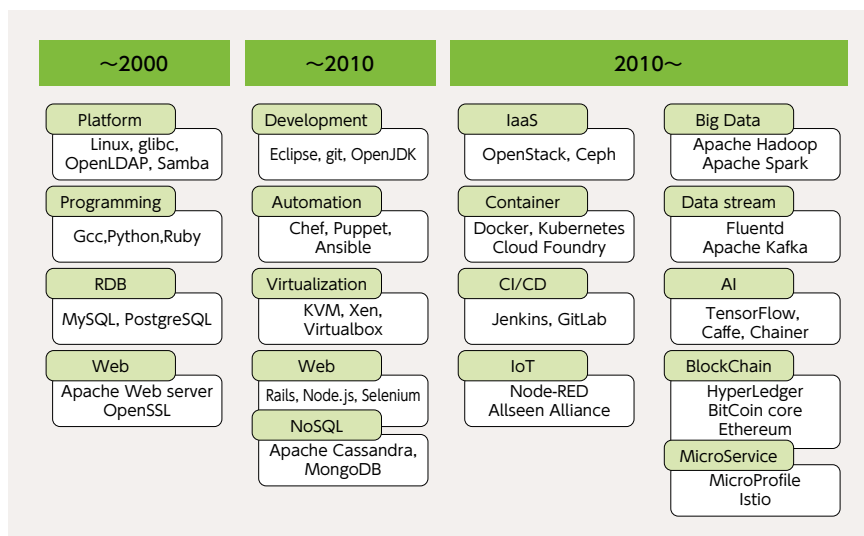


Fig. 1: OSS is increasing in various functional domains, and is driving the evolution of software technologies

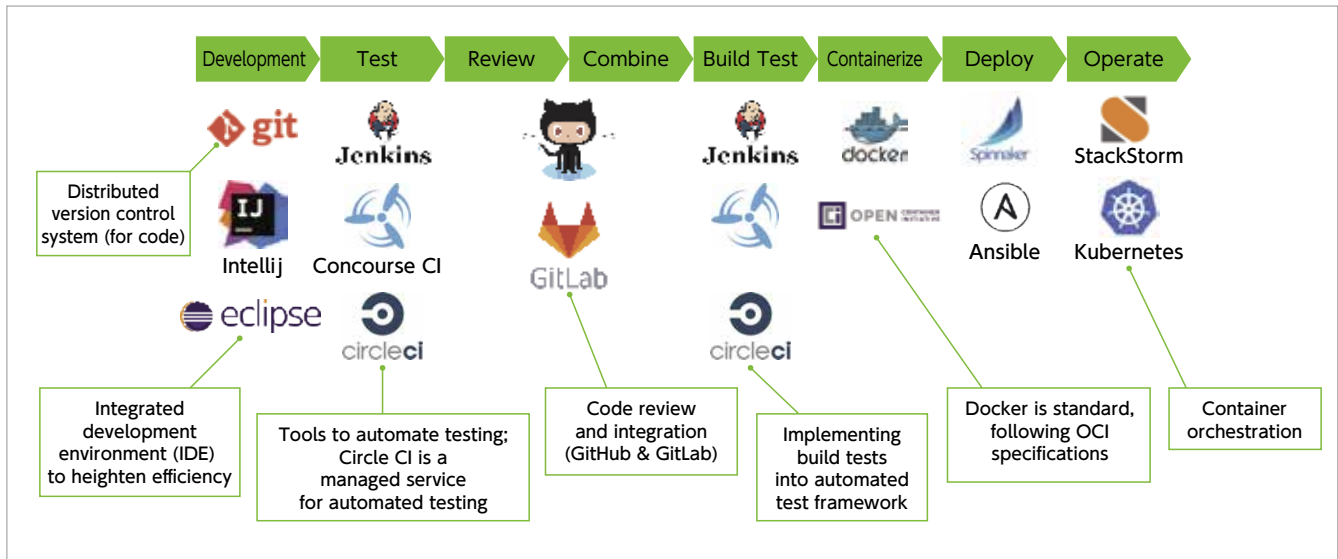


Fig. 2: Various OSS and services used in the service (application) development process and to accelerate it

which offered completely new value, and open source came to the forefront of technological development. As long as there are engineers, a combination of cloud and OSS makes it possible to create desired services quickly and at low cost. When this became apparent, it was clear that open source would prosper.

Thereafter, Microsoft, which had avoided and disliked OSS, declared "Microsoft loves Linux" in 2014. American company Oracle also in 2017, decided to entrust the future of the standard specification for development of Java applications for enterprises, "Java EE", to an OSS organization, the Eclipse Foundation. From this point forward, development continued under the name "Jakarta EE". As clear from the actions taken by both of these major commercial software companies, the utilization of OSS was now a foregone conclusion. At Fujitsu as well, we are working on OSS as the core technology behind software.

High-speed Development & CI/CD

Let us move on to the main subject. Now we ask the question, "What kind of technology is the OSS that supports speeding up application development?" (Fig. 2). Today, although OSS exists in numerous fields, OSS in these fields in particular is quickly evolving and essential for many companies. Some of the components are:

① Git

One OSS known to all engineers responsible for OSS and related development is "Git". For relatively large-scale OSS, such as Linux, engineers from all over the world collaborate on development. During the period, if the change history and development records, etc. for specifications and code cannot be shared properly, then there is a possibility of inconsistency between the code that one engineer was responsible for and the code that another was responsible for. Integration of code that has been under development for several months then fails, and various bugs will be triggered when it is added.

This is why the 3,000 to 4,000 Linux developers worldwide use the version-control system "Git" to record and track change history for source code, etc. Even under circumstances where the net cannot be accessed, there is a means (distributed type) for main tasks like checking history and recording changes. Likely more famous is the service distributed and co-developed by Git, "github.com". There are said to be 24 million users worldwide, and that it hosts 6.7 million development trees (clusters of source code).

The result is that using Git for co-development is today becoming an essential skill for software development. Though it is a Linux system, it can also be used from Microsoft's "Visual Studio" development environment,

and naturally, these skills are also taught in training for new employees at Fujitsu.

② CI/CD

The program that constitutes an application is itself a set of source code that allows for various functions to be performed. In other words, the code handled by each engineer is integrated, and a program is developed that has a variety of functions as one group. At this point of time, the timing of code integration (build) and testing is important.

Compared with testing after several months of coding, if a new build is made and tested each day, problems can be eliminated early, and the amount of rework necessary to repair bugs is reduced. This is why it is desirable to create builds and test the code frequently; however, this can be a heavy burden as it takes time to build and test manually.

This led to the arrival of "Continuous Integration (CI)" that continually performs repeat builds and tests, and test-automation OSS for that purpose. "Jenkins" is widely used, but recently a kind of functionality called "pipeline" has become considered important. Pipelining splits the steps of the process going from source code to finalizing an application into stages. Comparing this with simply creating and testing builds the difference is that it visualizes what occurs at what stage, which makes it easy to determine where problems are.

The idea originated from the OSS called "GoCD", but currently tools such as "Concourse CI" and "GitLab CI" supports the pipeline. Released in 2016, "Jenkins 2.0" strengthened pipeline, and the extension "Jenkins Blue Ocean" allows for pipeline control with a sophisticated UI.

Meanwhile, if you quickly provide what you have quickly made as a service, feedback can be obtained from users. Based on that, improvements can be provided, and to keep this cycle of getting feedback and making improvements going, which is extremely important when it comes to customer experience. Repeating this cycle in this way is called "Continuous Delivery (CD)".

Though in some cases this is covered by extending the pipeline for CI, OSS for CD has also appeared. For example, the largest VOD distribution company Netflix and Google have been developing "Spinnaker" that incorporates techniques such as those used for deploying applications on a cloud like AWS.

One specific example is "Canary Deployments", which is a service updating method/technique. This method simultaneously deploys the application and a new version of the application in a service on a cloud, and it directs a small percentage of user traffic to the new application. If there are no issues with the new application, then the new version replaces the old for all users. By doing this, the service can be updated on a continuous basis without greatly affecting the entire service.

③ Operation Automation

To develop new applications one after another, automation of operations is essential. This is because a variety of tasks must be performed with different dimensions than just installing software on a PC in order to operate an application, such as those related to securing and setting up memory and storage, network-related settings, incorporating an external library, etc. Moreover, when running the same application on 100 servers, there is a lot of time required to set it up manually.

Operation automation software covers this issue. If the settings are written as code, that is to say a configuration file has been created, the server environment can be automatically constructed based on that. There are OSS such as Chef, Puppet, and Ansible, but the most in demand is Ansible, which defines system operations by writing configuration files from "expected results". There are many modules, and of particular note is that most things can be done without writing a new configuration file.

New OSS is increasing as a result of the spread of CI/CD. One example is "StackStorm" that brought the idea of "IFTTT" from smartphone apps to the world of operations. In response to an event, you can activate a corresponding action. For example, when an event occurs such as instructions come from a web screen,

server failure is detected, or a test succeeds or fails, necessary parameters are automatically set that make it possible to boot up Ansible.

Container Technology and Kubernetes

As explained previously, distributed development of program code and CI/CD are contributing to speeding up development. However, there are still some inadequacies. For example, when someone adds changes to an environment created by automated operations, the next CD may fail for unexpected reasons, and creating a configuration file becomes incredibly complicated when trying to set it up for multiple OS versions, etc.

To solve these problems, PaaS development vendor dotCloud (now, Docker) developed the container technology "Docker". Simply put, it is a type of virtualization technology, and can accommodate the software and settings necessary for operation in one package (container) (**Fig. 3**). Compared with existing virtualization such as VMWare, since it does not take in the OS, kernel, drivers, etc., it is lightweight (small in size), and since the various requirements necessary for operation are packaged on the developer side, the burden on the operator side is reduced.

Docker became OSS in 2014, and now Docker containers support not only Linux OSs, but also can work from Windows Server 2016. Containers formatted to run on Linux do not run on Windows, but they can run on many versions of Linux without problems, such as CentOS, Red Hat Enterprise Linux, and Ubuntu. While it

should still be tested, since the Linux kernel emphasizes compatibility with older versions, differences in OS versions are less likely to lead to problems.

In the meantime, although Docker developed the container structure, an organization called the Open Container Initiative (OCI) was established in 2015 with the aim of creating more open container specifications. In 2017, OCI's container specification ver. 1.0 was released. Fujitsu is the only Japanese company to have participated as a member of the OCI since its inception, and have been working with Docker, Amazon, Microsoft, Red Hat, and IBM, among others.

Now, what happens when you combine the aforementioned CI/CD with container technology? A smooth flow can be constructed where the application at the development site has a build, it is packaged in a container, and it is then deployed as is to a beta environment and a production environment. This is an impressive level of progress, but there are still more to go.

A service (application) is composed of a combination of numerous programs. For example, a program for displaying the UI, a program for calculating prices, a program for managing user information, and so on. Therefore, in order to run the application, it is necessary to effectively combine multiple containers storing these programs and have them work in cooperation. It is necessary to give each container a name, deploy them to appropriate servers and clouds, control their start and stop, allow container-to-container connection by name, and also need load distribution and apply security features.

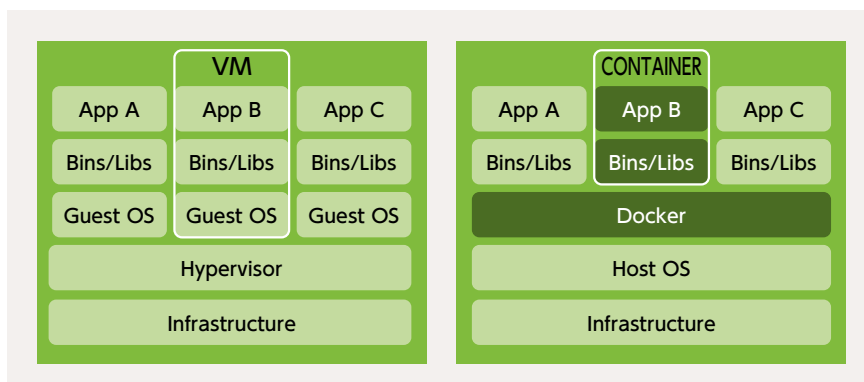


Fig. 3: Differences between hypervisor virtualization technology and container technology (from Docker website). Since a container virtualizes the OS, it is possible to operate many containers on 1 OS without them impacting each other. Compared with hypervisor, which virtualizes hardware, has the advantage of high portability.

This is called orchestration. What we need is something to play the role of a conductor that can direct all the instruments and players, and for that purpose, Google developed the OSS "Kubernetes" (Fig. 4). When using Kubernetes, after designing a service framework, you can construct services to fit the containers with the appropriate functions on it. Even on the operation side, it will assist with scale out and rolling updates (updates done without complete cessation of operation), etc. Kubernetes provides functionality to abstract the APIs of servers, storage, and networks, and conceals the individual specifications of cloud APIs from users.

Kubernetes is presently managed by the Cloud Native Computing Foundation (CNCF) (Fujitsu has also participated from its founding), and includes participation from 3 major clouds (AWS, Azure, GCP), as well as over 160 user companies. It is without a doubt the real standard in container orchestration.

Microservices

We have taken a look at Docker containers and Kubernetes orchestration. From the perspective of application development and deployment, these are component technologies and not environments used

by service developers. It is important to be aware that service developers actually use PaaS, and in particular, "Cloud Foundry" and the "OpenShift Container Platform".

Now, even if code development, builds, testing, and deployment can be done at high speed using the aforementioned technologies, there remains another hurdle to overcome. This has more to do with how we think about application development than technology, and is a problem related to architecture. For instance, in the case of a large service provider offering a variety of functionality (applications), since even when making changes to one part, it is necessary to test the full range of affected areas, thus a certain amount of time is required. Also, when modifying a program that constitutes a certain service, again it of course takes time to modify other related programs.

In order to resolve this issue, it is desirable to make many small services independent of other services, and then combine them to form a large service. This way it takes less time to modify one service, and when making modifications, they do not impact other services. This sort of design guideline is called Microservice architecture. In practice, it defines the API of each service, and ideally is designed to even maintain API compatibility.

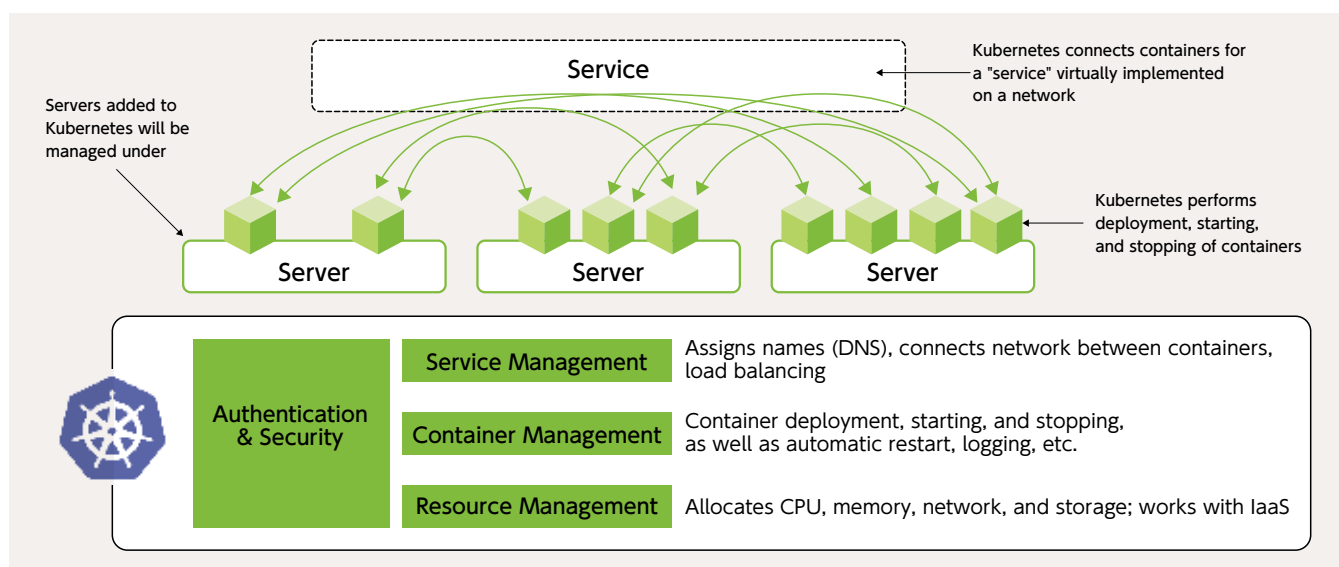


Fig. 4: "Kubernetes" is establishing itself as the standard of an orchestration technology for operating a large number of containers together

In other words, in Microservices, services are joined together by APIs. Saying that we are connecting services to services via APIs, some readers may recall Service Oriented Architecture (SOA), but be aware there are 2 major differences. One is that SOA is focused on lowering development and maintenance costs by reusing services. Also, with Microservices, in order to evolve small independent services quickly, a key point is speeding up creation.

Another distinction is that with SOA the focus is on the functionality of an Enterprise Service Bus as a structure to ensure connectivity with standardization and centralization, whereas with Microservices, the P2P framework using REST is adopted. This includes the presence of containers and clouds, and the evolution of the development environment described earlier plays a major role.

As a matter of course, if service granularity is reduced and it becomes difficult to oversee things in terms of cooperation between services, security, operation monitoring and management, etc., a technique for seeing the whole picture becomes necessary. Microservice are still under development, and although they have not yet reached wide-scale adoption, to overcome this situation, major vendors have established MicroProfile with the

aim of standardization of Microservice technologies using Java. MicroProfile is being developed with functions such as fault tolerance, health checks, trace logs, and authentication as its priorities.

Fujitsu has also recognized that a MicroProfile geared towards companies that promises to provide impressive Java assets for structuring company systems, along with easy appropriation and connectivity, is a clear winner. Fujitsu released a MicroProfile implementation as an open source in 2017. Fujitsu is the only company participating in and providing MicroProfile in Japan, and we plan to contribute to MicroProfile with the highly reliable technology and techniques cultivated using Interstage.

One final thing, I would like to touch on "service mesh" technology that is gaining attention in relation to Microservice (**Fig. 5**). Service mesh maintains the independence of each service in Microservice application, while acting as a technology to control governance at the center. For example, providing load balancing, routing control, security, visualization, etc. of Microservice. Fujitsu also have plans to incorporate Istio in products and services, which is becoming the de facto service mesh.

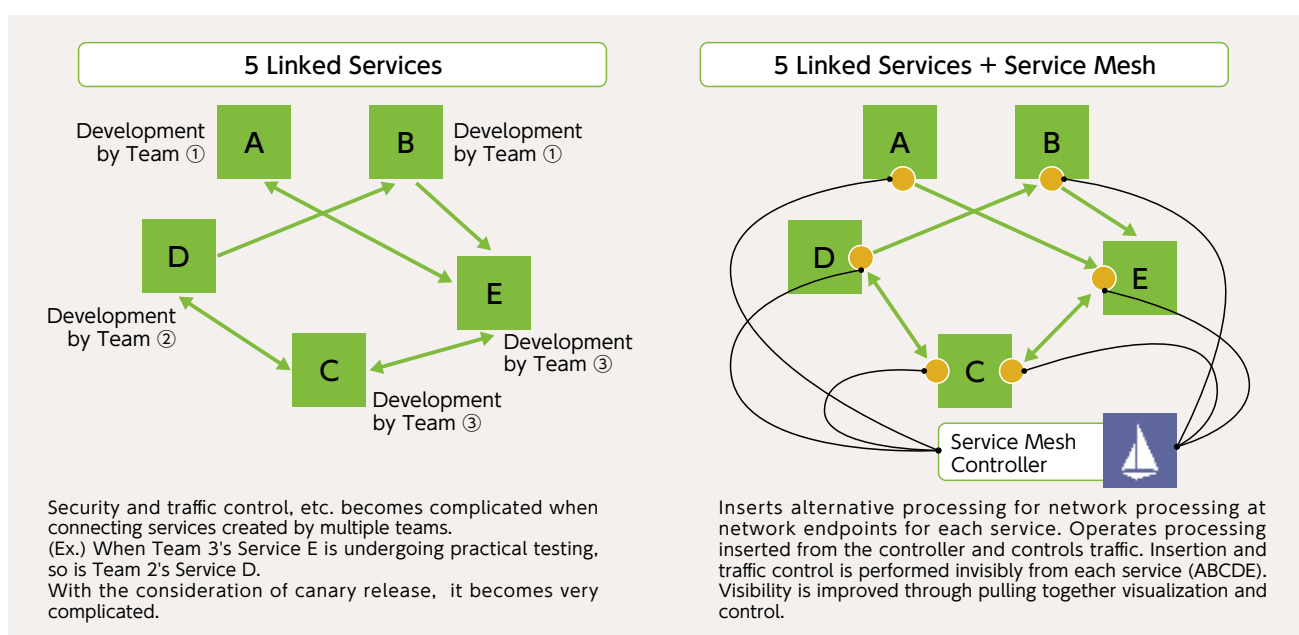


Fig. 5: Microservice service mesh; centralizes management while distributing endpoint nodes

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