# NTT DATA Technology Foresight 2017


NTT DATA
Global IT Innovator

# Looking ahead :

## Technology trends driving business innovation.


**NTT DATA Technology Foresight is the "outlook and technology trends of the near future" that is derived by NTT DATA once a year. It finds the challenges our future society will face at an early stage, and it serves as a compass to promote the creation of new value.**

**We aim for the betterment of society by depicting a future vision and achieving it together with various customers through foreseeing the impacts future technology will have on societies and businesses.**

**At NTT DATA, we incorporate NTT DATA Technology Foresight into our management strategy, and we are committed to technology development and service creation that anticipates changes in the business environment.**

NTT DATA
Technology
Foresight

## IST Information Society Trend

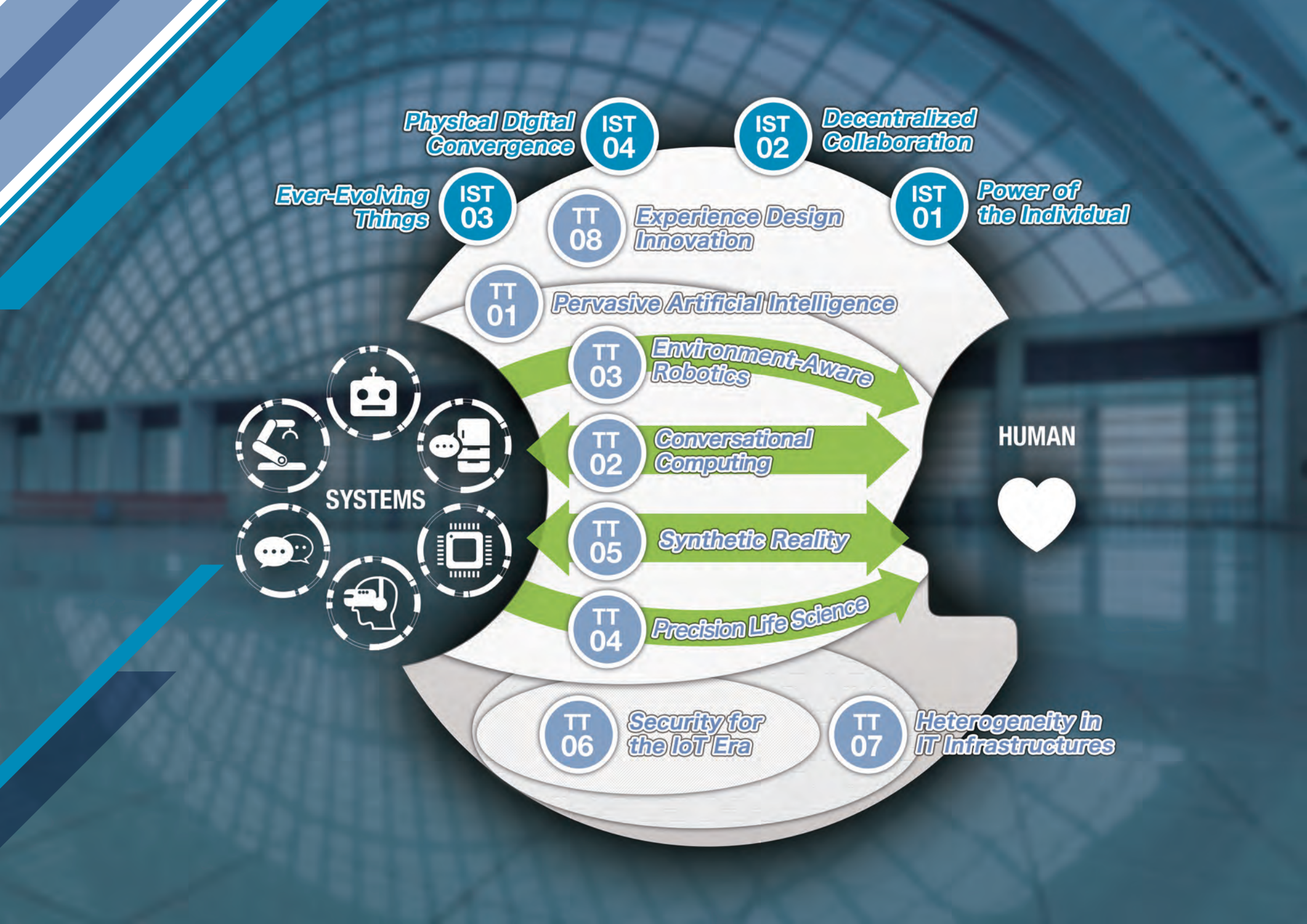
# NTT DATA Technology Foresight 2017 has compiled 4 information society trends.

The digital world has become a material part of our daily lives.We are heading toward a society in which increased value will be provided via the Internet. In addition to the growing influence of individuals, open participative collaborations are revolutionizing workplaces and societies. As Information Technology (IT) advances, restrictions in the current society will be overcome and the structure of society will be transformed.

## TT Technology Trend

# NTT DATA Technology Foresight 2017 has compiled 8 technology trends.

First, Artificial Intelligence (AI) is identified as a central technology that has become increasingly important. Three topics related to AI are covered within the research: conversational computing, robotics, and precision life sciences. Second, synthetic reality, a technology that is transforming the interface between humans and systems, is discussed. Third, the advancement of IT infrastructures and cybersecurity are included as important trends. Lastly, experience design innovation has also been added as a technology trend.


Physical Digital Convergence
IST 04
IST 02
Decentralized Collaboration
Ever-Evolving Things
IST 03
IST 01
Power of the Individual
TT 08
Experience Design Innovation
TT 01
Pervasive Artificial Intelligence
TT 03
Environment-Aware Robotics
TT 02
Conversational Computing
TT 05
Synthetic Reality
TT 04
Precision Life Science
SYSTEMS
HUMAN
TT 06
Security for the IoT Era
TT 07
Heterogeneity in IT Infrastructures


ormation Society
ticipate four key trends will have significant impacts
our clients' medium to long-term business.
nformation Soc
We anticipate fo


NTT DATA
Technology
Foresight

# Information Society Trend

*We anticipate four key trends will have significant impacts on our clients' medium to long-term business.*

**IST01** Power of the Individual

**IST02** Decentralized Collaboration

**IST03** Ever-Evolving Things

**IST04** Physical Digital Convergence

# IST 01

Power of the Individual

## Information Society Trend

We anticipate four key trends will have significant impacts on our clients' medium to long-term business.

# Power of the Individual

*The society that is individual-centric is urging the transformation of the current systems. Varied individuals are encouraging the restructuring of businesses, increase of options and transformation to a more flexible society.*

## Narrowing the Information Gap

The spread of the Internet has narrowed the formerly unbridgeable gap in the ability to distribute information between enterprise and consumers, employers and employees and large businesses and small-to-medium-sized businesses. The diffusion of social media has also increased an individual's ability to spread information, giving rise to a considerable pressure on providers. In the manufacturing arena, lower prices made possible by mass production and uniform service can no longer meet diversifying consumer needs. This is causing a shift from mass production to high-mix, low-volume production and even to the personalization of products in accordance with consumer requests. In addition, significantly lower switching costs between providers and brands of products and services have strengthened the relative power of consumers. A recent trend is consumerization, where innovation occurs in consumer markets ahead of business markets, after which the innovation is imported to front-line businesses.

The reduction of the gap in the ability to access information between the national government and citizens has resulted in significant changes in politics, the economy and social life as a whole. Vox populi, which used to be oppressed, and sharp individual opinions now enjoy much greater exposure, excessively demanding their incorporation into policies. Since a reduction in the sense of belonging and a rise of populism are also being seen, in some cases, unexpected results are occurring in elections and referendums. Finding an equilibrium point is expected to take a little more time.

## Development of Individualization

Personalization is shifting toward individualization. Stronger advocacy of individual demands, along with the new ability to acquire accurate information on individuals and their behaviors, have made it clear that services that segment customers simply by attributes, e.g., age and sex, and purchase histories, do not attain maximum results. For example, analysis of information distribution via social media, and information on families and assets, real-time analysis of location and individual situations and behaviors, are now being combined to increase contract success and likability rates. One case reported that individualized rewards program based on personal taste and interest lead to more than ten thousand times as many variations of rewards program, doubling the rate of utilization. To achieve customer satisfaction, it is imperative that providers of products and services restructure business models. In the medical field, treatment methods that incorporate genetic information, patient personality and living environment in addition to the state of illness and comorbidities, will likely become more commonplace. Although concerns about privacy may make the application of these methods optional, evidence of the significant impact on users will likely promote continued adoption of these techniques.

As a system that supports individual needs more accurately and rapidly, 3D printing is expected to expand rapidly in the future for prototypes, finished products and parts. Spread of 3D printing will lead to the shift of manufacturing locations closer to final consumption, enabling even individualization of manufacturing processes. This may cause the restructuring of supply chains as a whole. A recent IDC study forecasts that the 3D printing market will grow at the CAGR (Compound Annual Growth Rate) of 22.3%, with a market size of approximately 29 billion dollars in 2020, almost 2.2 times the size of the market in 2016*[1]. Expansion of 3D printing is expected especially in the dental and medical implant treatment fields.

## Rise of New Businesses

Digitization has caused rapid changes in the business models of existing companies. For example, the way to purchase music has evolved from record albums and CDs to individual pieces of music, and consumers can subscribe to a newspaper on an article basis, radically shifting distribution systems. The service industry has seen the appearance of FinTech companies, which specialize in their areas of strength to provide functions to existing financial institutions. This indicates a change from provision of uniform service to provision of service restricted to certain functions. Some financial institutions offer only digital services without providing any branch offices, while other banks have expanded their functions to meet customer demands. In place of large companies offering uniform services, the distribution arena is experiencing unbundling, where a selective combination of multiple startups can provide similar services. An increasing number of construction and healthcare companies are also providing highly specialized services by narrowing down to certain functions. Startups have the advantage of proximity to customers.

Digitization has caused standardization and lowered transaction costs, decreasing the advantage of one company providing all functions. Large organizations are also hindered by bureaucratic structures and slow decision making resulting in the need for a system to create and adopt innovations. For this reason, collaboration between large companies and startups has become more popular. In addition, acceleration of the IT revolution is blurring the boundaries between industries. For example, some IT-related startups are entering the automobile and space industries.

## Expansion of On-Demand Economy

The on-demand economy, in which products and services are provided based on demand, continues to grow. In the United States over 40% of adults have used this type of service. The spread of smartphones and social media has enabled more effective matching of supply and demand, leading to more efficient use of idle assets.

Because consumers can now become providers, an increasing number of markets are in flux. While the sharing of cars and lodging facilities are generating resentment from the taxi and hotel industries, users unsatisfied with the inflexible service of the existing industries support new entrants not subject to regulations, causing existing business model disruption. This trend has even impacted the automobile industry, which has entered the business of sharing vehicles, despite the potential negative effect on sales volumes. In tandem with the expansion of service types, such as the home delivery of food and housekeeping service, the number of users is increasing. While a majority of users are currently young adults who are trend-conscious and knowledgeable in IT, the market for this type of business is expected to expand in the future.

## Penetration of the Gig Economy*2

An increasing number of workers, especially in advanced countries, are freelancing instead of belonging to a specific company or organization, thus propelling the diversification of individual work styles. In addition to digitization and mobilization, which has separated work from the workplace, expansion of the on-demand economy and crowdsourcing has paved the way for utilization of the abilities and resources of individuals. This is one of the key factors in increasing the number of full-time and part-time freelancers. In particular, more individuals with highly specialized skills have access to global markets and select a job regardless of location that takes advantage of their abilities. The United States has approximately 53 million freelancers, approximately one third of the workforce. This number is expected to grow above 50% of the workforce by 2020*3. Similar trends in the number of freelancers can be seen in Europe and Japan, with large companies increasingly hiring freelancers. Employers which leverage freelancers to strategically use specialized expertise instead of just cost reduction and adjustment in employment volume, experience enhanced competitiveness. If companies and organizations continue to utilize external skilled workers for important tasks, organizations will become more open and flexible.

## Experiencing the Power of the Individual

The power of the individual is already fundamental in the world, bringing changes to the relationships among entities in society. Although a negative aspect exists where fake online news is affecting even politics, the impact of the individual will likely continue to expand, encouraging modifications in industries, reexamination of regulations and construction of new systems. The power relationship (power balance) in society will also likely continue to change. As a result, companies need to look beyond these changes and adequately prepare for next steps in the future.

*1 https://www.idc.com/getdoc.jsp?containerId=prUS42211417

*2 Short-term contract type for individuals in the labor market

*3 https://freelancerworldwide.com/the-freelancing-business-is-booming-in-europe-and-america/?lang=en

# IST01 CASE STUDY

Information Society Trend 01

We anticipate four key trends will have significant impacts on our clients' medium to long-term business.

## Discovering Ventures Worldwide Through Business Contests

In today's society, venture capital companies play a vital role in solving business problems and encouraging innovation. To inspire such efforts, approximately four years ago NTT DATA launched an open innovation forum called "From the Port of Toyosu." Attendees included NTT DATA's customers, NTT DATA, and startups firms. Specifically, the company hosted monthly meetings for startups and key industry figures to deliberate new business creation opportunities.

NTT DATA also initiated a series of bi-annual, open innovation contests, during which new business ideas are solicited from a variety of sources. Initially, four contests were held in Japan. The company then expanded the program in 2016 to ten cities in nine countries worldwide (Tokyo, San Francisco, London, Tel Aviv, Toronto, Madrid, Barcelona, Singapore, Beijing, and Sao Paulo). NTT DATA received more than 200 applications in response to the designated theme of new technologies and business models*1. After the selection process, the grand finale was held at Toyosu, Tokyo in March 2017.

The objective of NTT DATA's business contests is to provide scale-out opportunities through a business partnership with NTT DATA. The winning company receives business assistance toward the targeted business creation in cooperation with the theme owner (the business division). Winning ideas have launched businesses in cooperation with NTT DATA in areas such as Fintech and energy management.

***1** NTT DATA (Japan), everis (Spain), NTT Data UK (Britain), and NTT Data, Inc. (USA) were the four theme owners.

# IST 02

Decentralized Collaboration

**Information Society Trend**

We anticipate four key trends will have significant impacts on our clients' medium to long-term business.

# Decentralized Collaboration

*Many people and all kinds of things will be linked to the Internet, resulting in innovation. Each component will act autonomously, and a new ecosystem will be built where relationships will change dynamically.*

## Peer-to-peer Society

The Internet, for which no centralized management mechanism exists, has changed the information distribution system via peer-to-peer networks, where users are interconnected on an equal basis. Organizational structures are being flattened and decentralized and open systems are spreading throughout society at large.

## Building Collaborative Economy

All types of information are circulating on the Internet, which is used by more than 3.4 billion people in the world. Large amounts of knowledge and know-how are contained within online encyclopedias, which let anyone edit topics at will. In this collective intelligence approach, each author contributes the knowledge from his/her specialty area. Because inaccurate information is corrected over time, encyclopedias created this way are comparable in accuracy to those edited by experts. Some believe that these encyclopedias offer detailed information that ordinary encyclopedias do not address.
Other examples for similar uses of collective intelligence include: investigating the causes of illnesses and developing therapeutic methods based on various information provided by the patients; and participatory sensing where individuals' smartphones are used for monitoring the environment and acquiring data on traffic conditions. While ordinary sensors are more precise than participatory sensors, they are expensive and thus measurement locations are limited. Although sensors such as smartphones may be lower in precision, collecting huge amounts of such data over wide areas makes overall errors low. Participatory sensing is also used for purposes such as map information updates and urban planning.
To encourage open innovation, an increasing number of companies are utilizing crowdsourcing, which solicits knowledge, know-how, services and work from the general public. Its uses have expanded to include development of new products and services, problem-solving ideas, specialized expertise and skills. Professionals also use crowdsourcing to leverage their skills and expertise by identifying opportunities.
Crowdfunding solicits funds from the general public, enabling innovation by opening new opportunities of funding to startup. It diversifies financial risks and introduces new a decision-making mechanism for financing that enables even companies without collateral to raise funds if they win support for innovative ideas. A growing number of large companies as well as small businesses use crowdfunding for development of new products because they can derive benefits such as improvement of ideas during the development stage and prediction of reaction via communication with the market.

## The Growth of IoT

The Internet of Things (IoT) has always existed as a concept, but not until recently has it started to become a reality. By adding a sensor and a communication feature, a variety of things can be converted to digital devices, including smartphones, information devices and household appliances, allowing them to report conditions and changes in devices and environments and to remotely monitor, manage and control devices. By 2020, as many as 20 to 30 billion devices are predicted to have access to the Internet*[1234] , coordinating with one another. Autonomous problem avoidance and condition optimization delivered by artificial intelligence technology and big data analysis are also anticipated to become commonplace. Some examples include demand control for electricity by balancing and prioritizing the usage of home appliances, and collision avoidance of self-driving cars and drones by mutual communication.
In manufacturing, IoT brings an industry revolution called

Industrie 4.0 or the Industrial Internet. With the Industrial Internet sensors installed on parts and manufacturing machinery are linked to people (laborers), production plans, and processes to optimize the entire lifecycle of a product, including procurement, production and post-shipment. It is now possible to change a production plan on a real-time basis in accordance with changes in the market, replace a production process in response to a mechanical failure and improve operational efficiency by monitoring product conditions. This is giving rise to new business models aimed at increased profitability by optimizing machine operation. By coordinating the entire supply chain including distribution, plans are underway to detect a delay in the arrival of a specific part ahead of time to optimize the production plan that covers multiple factories.

## Emergence of Blockchain Technology*5

Virtual currencies do not have an issuer such as a national government or central bank. Instead, it ensures reliability with decentralized, distributed ledgers and forms an 'Internet of money' that circulates values. Not only can virtual currencies be used as a means of settlement in lieu of real currencies, they can also be used in coordination with tangible and intangible assets, thereby managing and transferring rights and contracts. Because blockchain technology has high transparency and are immutable, they are gradually becoming used in the registration of real estate, distribution of copyrights and management of medical information. Decentralized e-commerce and market forecasting, where there is no central management entity, are also starting to appear. Usage in voting and notary service are also being sought.

A Distributed Autonomous Organization (DAO), where no centralized governing system exists, is operated autonomously according to the predetermined rules. Although the characteristic that the transactions on the blockchain cannot be altered or canceled, if once recorded, may be an issue, DAOs have potential to be used for shared services, investment funds and asset management. For example, Estonia has implemented a notary service for marriages, births and contracts using e-Residency, which is used by foreign nationals. ID issuance, notary service, and other services offered by a virtual nation also have the potential of widespread use in the future as a means of verification without depending on a national government.

## Rise of API Economy*6

Services are increasingly integrated by virtue of inter-company coordination. Sharing information and systems leads to coordination that involves a wide variety of parties concerned, including those in different industries. This in turn leads to the creation of highly convenient new services and innovations. Examples include: the coordination of flight information with airport transportation services and hotel reception; utilization of information obtained from automobiles for proposing insurance and maintenance services and the process for searching for a house to purchase on a smartphone and applying for a home loan. Because services are automatically proposed based on individual situations, users do not have to spontaneously find services by themselves. This will lead to an easy decision-making for purchase. Contextual commerce integrates social media and payment services, enabling an on-the-spot purchase of a product a user wants. This type of commerce is changing consumers' purchasing behaviors.

## Migration to a Decentralized Society

Although only some progressive organizations are currently practicing a decentralized approach, it is anticipated to spread widely as a system of value exchange that does not need an intermediary. Of the current systems with centralized management, those that do not have central managers from the beginning such as international payments and remittances, and tasks of governmental agencies suitable for outsourcing to the private sector, are considered to be the best initial candidates for the decentralized system. On the other hand, many tasks are not suitable for the decentralized system, including transactions of listed stocks, where situations may change instantaneously and areas that require substantial decision-making.

Shutdowns of the Internet by a government in 2016 occurred as many as 56 times in 18 nations, including partial shutdowns*7. In a truly open, decentralized society, even the government could not shut down such services. An open, decentralized society is one with high transparency and no conflicts. At the same time, it is a society with no leader. The speed and spread of the migration to the decentralized society will likely depend on future system planning and the degree of societal acceptance.

---

***1** http://www.gartner.com/newsroom/id/3165317

***2** IDC, "Worldwide and Regional Internet of Things (IoT) 2014–2020 Forecast: A Virtuous Circle of Proven Value and Demand," May 2014.

***3** Ericsson, "Ericsson Mobility Report," November 2016.

***4** IHS Technology, "IoT platforms: enabling the Internet of Things," March 2016.

***5** The core technology for virtual currencies such as Bitcoin.

***6** A trend for a company to disclose (or create a platform for) its API (application programming interface), a mechanism to call a software function, thereby making the coordination of information systems with other companies easier and creating new values and businesses.

***7** https://www.accessnow.org/keepiton/

# IST02 CASE STUDY



## Providing an Integrated Ecosystem that Assists Electric Power Providers

The full liberalization of the retail electricity business provides significant business opportunities. For example, Japan's retail electricity market is estimated to be approximately 7.5 trillion yen, and a variety of power providers are competing in the market. However, these new entrants have many challenges to continue to operate successfully in the electricity market.

To assist, NTT DATA, Kyowa Exeo Corporation, and Fuji Electric Co., Ltd. have collaborated to develop and provide "ECONO-CREA", a cloud service to provide one-stop shopping for all the functions necessary to operate successfully, within the electric power retail businesses. The service offers comprehensive customer management and supply and demand management services including a real-time and detailed prediction of the demand for electric power, electric power procurement via short-time sale and purchase, and formulation and monitoring of short- and long-term supply and demand plans.

"ECONO-CREA" cloud services blend the strengths of each member company, NTT DATA provides highly reliable cloud infrastructures based on its know-how of the retail business in a variety of industries; Kyowa Exeo Corporation supplies its finely tuned customer management system; and Fuji Electric Co., Ltd. offers its abundance of know-how on building smart communities. NTT DATA integrates all services to provide the required functions on a highly reliable infrastructure.

In the future, "ECONO-CREA" plans to expand its application platforms to focus on other application development vendors and open innovation, adding new services such as Customer Relationship Management (CRM) and Sales Force Automation (SFA).

# IST 03

Ever-Evolving Things

**Information Society Trend**

We anticipate four key trends will have significant impacts on our clients' medium to long-term business.

# Ever-Evolving Things

*Big data analytics will fuel innovation. Even after they ship, products will become ever-evolving things through functionality and performance enhancements. This in turn will boost customer value and promote business model transformation.*

## From Goods to Services

With the development of globalization and the expansion of digitization more products are becoming commodified. In the meantime, the transition from an industrial to an intellectual society has changed the sources of value from tangible things and assets to the use of intangible information, design and functions. The same product may have different values depending on the user's sense of value, situation and usage. In some cases, products have emerged from price-cutting wars by adding values ending up with an increased price point. The law of one price, which indicates the value attributes products, is being shifted to multiple prices, which mean value is derived from products by using them.

In the manufacturing industry, servitization that provides products as a solution is becoming popular, an accompanying paradigm shift from the idea that value exists in products themselves to the one that value is generated by using products. For example, customers who wish to shop efficiently and those who wish to enjoy a shopping experience look for different values such as the atmosphere of the store, service of the sales staff, etc. Redefinition of value offered to customers is also happening in the financial, medical, and social welfare fields.

## Analysis of Big Data

The development of IT has enabled all kinds of information produced by people and things to be accumulated. Real time analysis of varied and large amounts of information generated real time helps visualize the conditions of customers, markets, society and the environment. Signs of change and correlations that have been elusive can now be linked to: improvements in customer satisfaction; development of new products; diagnosis of illness; and development of medicines. While privacy and other issues must be considered, results may prevent problems based on the correlations of behavior patterns and the environmental conditions with success and failure, illness and accident and criminal action.

Analytical algorithms are the key to deriving value from big data. For example, analysis of customer attributes may generate different results depending on the data and analytical algorithms used. In the consumer finance industry, traditional financial behaviors have included revenues, debt balances and credit histories. In addition to these, an approach that determines the credit risks of individuals based on their overall information including financial behaviors traditionally overlooked and information seemingly unrelated to financial behaviors such as ways of signing a document, majors at colleges and postings on social media, is emerging. While demographic groups with no credit histories can now receive loans, which leads to the correction of some disparities, loans to applicants with high default risks have decreased, allowing some lenders to lower losses from defaults by more than 20%.

## Ever-evolving Things

Because automobiles, machines, consumer electronics, and other things are connected to the Internet, processes common in the world of IT are expected to be used widely in the physical world. For example, when software updates of computers and digital devices are applied to a wider range of things, users may be able to enjoy the advantages of added features and improved performance without trading in their things. While in the past, things were replaced whenever a new product with enhanced features appeared, it may become common to update only the software while

continuing to use the same device (hardware). If that happens, design concepts will change so that software will provide all kinds of features. Modularization, which enables that only parts of a device are replaced depending on software features and agile development methods, which are common in software development might be introduced.

Cars that can be converted to self-driving vehicles by installing software and robots whose functions expand by adding applications have already arrived. Robots that learn tasks and those equipped with AI (artificial intelligence) with self-learning ability also exist. It used to be that the difference of tangibility of goods and services originated other differences. For example, there was time difference between production and consumption of goods, while those of services were simultaneous. The value of goods was determined at the completion of production and deducted through consumption, while that of services was co-created by producers and consumers. Things whose value increases as they are used have made it meaningless to make a distinction between goods and services. This could create an impact on industrial classification and how depreciation is treated in accounting.

## Emergence of Smart Machines

Recent years have seen the emergence of self-driving cars, drones, robots and other machines equipped with AI (collectively called smart machines) that has self-learning functions and moves autonomously. The spread of smart machines is expected to change the roles and functions of both people and machines in society. For example, more factories and other facilities may become unmanned, with robots monitoring machines. Self-driving cars and drones will be handling logistics, and virtual assistants will be serving customers at banks and stores. Robots can already communicate with other robots to share what each has learned on its own. In the future, it is believed that smart machines will be also sharing perceptions, such as collision avoidance, acting in collaboration with one another. While society is human-centered, smart machines are expected to assume a central role in social infrastructure and control, giving rise to a restructured social system and processes.

## Human – AI Collaboration

Although AI now has the capability to beat top-class professionals in Japanese chess (Shogi) and Go through self-learning, this type of AI is specialized in specific skills. There is still no AI that possesses the overall high intelligence of humans. In light of the increasing dependence on decisions made by AI in the future, it may make sense to provide AI with a basic education that lets it make correct decisions similar to human children, allowing for versatility and high intelligence. Unfortunately, AI could also be taught impropriety by malicious developers, allowing it to make incorrect decisions or misjudge between right and wrong. With its increased use, AI will be expected to make decisions outside its expertise such as ethical problems. In short, it will be essential for AI to acquire common sense. Some non-profit organizations have already launched educational institutions which focus on AI. In the future, the education of AI may become critical. Meanwhile, if a smart machine (AI) causes an accident due to its self-learned ability, an issue will occur as to the extent of liability that may fall on the owner, user, manufacturer or software developer. Some have started to consider giving smart machines the status of a legal person, subjecting it to liability.

A study*1 reports that AI and robots will have an impact on the employment of 40% to 50% of a nation's labor force. In school education and worker training, it may be necessary to have humans learn high cooperativeness and creativity, which are difficult to substitute with AI. However, employment opportunities replaced by AI could exceed those newly created for humans. For this reason, it may be necessary to examine social system first including the social security concept, shorter workdays to increase the number of employees and the implementation of basic incomes.

## Strengthening of Cyber Security

It is believed that real-time situational judgment and continual communication among smart machines will help avoid accidents in the future. This could make the quality and reliability of communication functions even more critical. For example, if exploitation of security vulnerability causes a large-scale blackout or traffic jam, the entire society might become dysfunctional. Hacked smart machines might even start assaulting humans.

One way to avoid hacking is to refrain from being constantly connected to the Internet. However, this would make it impossible to take full advantage of existing information. Although strengthening countermeasures against cyber-attacks is required to ensure security, it will also be necessary to build failsafe systems for minimizing the impact of potential failures and for stopping unexpected actions of a smart machine.

*1 https://www.nri.com/~/media/PDF/global/opinion/lakyara/2016/lkr2016234.pdf

# IST03 CASE STUDY



## Making Uncrashable Vehicles through Analysis, Learning, and Prediction of Data

NTT is developing an application using edge computing to enhance automobile safety by using the vehicle's sensors, and sharing information about its surroundings such as distances between vehicles, roadside facilities, and the location of pedestrians carrying electronic terminals. Edge computing is a technology that enables real-time control of a network computer deployed near (on the "edge" of) the user by giving it data analysis, learning, and prediction functions. Because the analyzed results can be immediately communicated, it can provide drive assistance to an operating vehicle.

In 2016, NTT developed the concept of an uncrashable vehicle in a field demonstration in collaboration with Toyota Motor Corporation ("Toyota" hereafter) and Preferred Networks, Inc. ("PFN" hereafter). This demonstration used a combination of Toyota's drive assistance concept for the future using AI, NTT's edge computing technology and reliable wireless technology, and PFN's Deep Learning technology for collision avoidance and distributed processing. Specifically, model cars were used to create an environment of multiple cars in operation, and PFN's advanced AI learned the actions necessary to avoid collisions in circumstances that continuously change. Each car receives the results of learning from the edge server, enabling them to autonomously avoid collisions. In addition, high reliability was maintained using multiple wireless access methods. In the future, NTT will aim to establish an infrastructure technology to provide real-time information for more advanced drive assistance. This will include dynamic and accurate traffic space and surroundings information, analyzing, learning, and predicting traffic jams; and prioritizing emergency vehicles.

# IST 04

**Physical Digital Convergence**

**Information Society Trend**

We anticipate four key trends will have significant impacts on our clients' medium to long-term business.

# Physical Digital Convergence

*The physical-digital convergence will broaden in scope. People will freely go back and forth between the physical (real) and digital, and between offline and online without being aware of the borderlines. Restrictions in time, space, and ability will be relaxed; therefore, new values will be created.*

## Transition to Smart Cities

The United Nations estimates that the world population will be 11.2 billion in 2100 (medium variant projection), approximately 1.5 times the population of 7.3 billion in 2015*[1]. Although some advanced countries can expect an increased population via the influx of immigrants, a majority will face a dwindling population. To take efficient measures for expansion of social infrastructure and the growing demand for energy in regions where population will increase, and to avoid the risk of excessive infrastructure in regions where population will decrease, future urban planning should be shifting its focus from physical and technological measures, which support social infrastructure through construction, to digital measures with ideas and design, which complement the infrastructure through improved utilization density and rate.

For example, traffic jams can be eliminated by advanced traffic signal control, ridesharing and the implementation of self-driving cars. Power shortages can be addressed by the implementation of smart grids and demand response systems. In addition, a combination of remote monitoring and preventive maintenance will likely lead to a reduction in maintenance management costs and increased longevity of aging tunnels and bridges. In a smart city, physical infrastructure and digital information will be used in combination to optimize infrastructure.

Automobile manufacturers and IT companies are currently testing self-driving cars on the road, or are soon to reach this milestone. Technological development has preceded rule formulation until now. However, the U.S. Department of Transportation has already published its own guideline for self-driving cars, with the United Nations following to establish international standards. Although it will still take time to establish effective international rules, self-driving cars could be in practical use in the near future. Commercialization of autonomous, self-driving car technology will probably decrease individual ownership of automobiles. Buses will no longer need to run on specific routes according to a schedule, and there will no longer be a distinction between buses, taxis, shared cars or rental cars. The transportation system itself is expected to transition to a more flexible model where vehicles are run on demand. Urban planning will also shift toward self-driving cars and efficient vehicle dispatches.

The expansion of agricultural production is essential to support needed increases in food demand associated with increasing population. It is anticipated that digitization will lead to a stabilized food supply. For example, sensors are already measuring temperatures, humidity and soil conditions. Similarly, drones are spraying fertilizers from the air and monitoring crop growth. In addition, unmanned farm machines are plowing land and harvesting crops. Because the leading cause of poor crop growth is weather, farms are also using mesh weather forecasting data for optimal soil management. Improvement in the accuracy of harvest prediction models also enables the pre-arrangement of storage, transport, sale, and processing of crops, with an expected benefit of reduced wastage. Digitization efforts are also beginning to take place in the fishery and livestock industries.

## Changes in the Relationship between Machines and Humans

The machine-human relationships are changing. In the past, users interacted with machines according to the requirements of the machines. With intuitive interfaces similar to interactions with other people, humans will increasingly provide machine instructions using postures and facial expressions (image recognition) as well as words (voice recognition). A technology that can identify an individual without examining the face has also recently been developed, and the recognition rate of major voice recognition software now exceeds 90%. Technologies

have advanced to a level close to human capacity. Some predict that 50% of web searches will use images and voices by 2020. It is also expected that control of household appliances, reservations for restaurants and orders to e-commerce stores will be achieved by talking naturally to a smart home device. (Even switches and panels will disappear from household appliances). A household communication robot will not only be able to engage in conversations with a user, but also detect emotional changes or symptoms of an illness based on voice patterns, enabling it to mitigate discomfort. A robot which can detect changes in the user's body conditions immediately and notify healthcare staff will significantly help senior citizens to lead independent lives.

Companies and their customers are starting to use a service called chatbot, which uses text (written characters) and voice to communicate naturally. Applications of chatbot are expanding from travel reservations and shopping to taxi dispatches. Currently users need to call different chatbots that meet their needs, and communication is mostly text-based. However, in the future it is predicted that virtual assistants will converse with users using natural language, while controlling separate chatbots.

Individual authentication will no longer require cards or passwords. Instead, touch and conversation will allow for the detection of finger and voice prints, biometrically authenticating an individual. The days of humans adjusting to machines are being transformed into days where machines are adapting for humans. Autonomous self-driving cars can be considered an example of machines adjusting to humans. With a natural interface, the digital divide, which stems from not knowing how to use machines, will probably also disappear in the future.

## Relief from Restrictions

The spread of remote healthcare and telecommuting can be regarded as the evidence of the convergence of physical and digital worlds, which has enabled services to overcome the restrictions of time and space to come to humans. Whereas simple image and audio were used to overcome distances in the past, environments artificially created by VR (virtual reality) technology and telepresence will make the experience more realistic. AR (augmented reality) technology, where the real world and digital information are superimposed in real time, and MR (mixed reality) technology, where virtual objects are combined with the real world, are also gradually coming into use as well. Although the need for a head-mounted display was a bottleneck to the spread of VR, smartphones can now easily provide the experience. The main uses of VR are currently entertainment-related such as games. However, education, sports training, simulations, telework and remote support are starting to use VR. AR is also becoming familiar in game apps. Now a wider use of AR is starting to include tourism, events, promotions, construction and interior design. Applications focused on agriculture and fishery are also expected.

Wearable terminals, which measure and record biometric information and track physical activity, can, if worn at all times, capture health conditions. This technology may lead to the early detection of factors leading to illness and/or changes in symptoms, enhancing preventive medicine. The relationship between medical professionals and patients may change. The attitude toward healthcare may also change from seeing a physician when feeling sick to ongoing monitoring and communications.

## Transformation to Digital Business

The convergence of physical and digital worlds is accelerating the transformation of companies to a digital form of business. In the past, humans made all business decisions. However, in digital business, machines, things and other business components will also make appropriate decisions. For example, if, in a factory with advanced IoT the delivery of parts are delayed, machines and things in the factory may decide to switch production lines to manufacture different products. Humans would react based on this decision. There is a high probability that existing organizations and systems cannot optimize the benefits of digital business. As a result, not only the company, but the industrial structure itself will probably change.

These changes will also transform the overall social system. As gaps exist in the ability to adapt to rapid changes, new social disparities may arise. A gap between global and in-country rates of change may lead to economic imbalances. Accordingly, it may be necessary to start building a culture through education that tolerates more rapid changes.

*1 United Nations, Department of Economics and Social Affairs, Population Division (2015). "World Population Prospects: The 2015 Revision, Key Findings and Advance Tables."

# IST04 CASE STUDY



## Applying 8K Super Hi-Vision Technology to Remote Medical Care

In collaboration with NHK Engineering System, Inc., NHK Educational Corporation, NTT Communications Corporation and SKY Perfect JSAT Corporation, NTT DATA INSTITUTE OF MANAGEMENT CONSULTING, Inc. has launched a research and verification project for applying 8K Super High-Vision technology ("the 8K technology" hereafter) to medical care. This technology records and displays super high-definition videos. The research is part of the "Verification of a remote medical care model utilizing the 8K technology," commissioned by the Ministry of Internal Affairs and Communications in Japan. The purpose is to analyze the application of 8K technology to remote medical care. Underlying this effort, is Japan's aging society which requires increasing levels of medical care using existing resources.

The 8K technology can take, record, transfer and display super high-definition images with 33 million pixels, approximately 16 times more than traditional hi-vision pictures. This enables the transmission of visual medical information with unparalleled detail and reality, making detection of slight changes in symptoms possible. The companies have selecting two areas in which to focus this technology. The first is to help alleviate shortages of pathologists in Japan by enabling remote diagnosis. The second is to assist with the need for specialists in remote islands and land areas. The study will evaluate differences in treatments and results between using 8K videos and in person observation. The company plans to use 8K technology to build a remote pathological diagnosis and treatment assistance system, as well as a super high-definition image information database.


nology Trends
owing eight technology trends are expected to have the biggest influence in the coming
Technolo
following eight technology trends are expected to have t


NTT DATA
Technology
Foresight

# Technology Trends

*The following eight technology trends are expected to have the biggest influence in the coming years.*

**TT01** Pervasive Artificial Intelligence

**TT02** Conversational Computing

**TT03** Environment-Aware Robotics

**TT04** Precision Life Science

**TT05** Synthetic Reality

**TT06** Security for the IoT Era

**TT07** Heterogeneity in IT Infrastructures

**TT08** Experience Design Innovation

# TT 01

## Pervasive Artificial Intelligence

**Technology Trend**

The following eight technology trends are expected to have the biggest influence in the coming years.

# Pervasive Artificial Intelligence

*Widely accessible advanced machine learning will result in expanded use of AI (Artificial Intelligence). AI will improve convenience, resolve intellectual labor shortages, and drastically advance science. Mastery of AI will become a critical component of competitiveness. the industrial structure.*

## Pervasiveness of Deep Learning

In 2016, the big news on Artificial Intelligence (AI) was the development of a technology called deep learning, which mimics the brain cell activities of animals. Deep learning is expected to have higher accuracy than past AI technology and features extraction, which can also be automated, making it available to a wider range of users. In addition, open environments and software are accelerating advancements in deep learning, and TensorFlow, DSSTNE, CNTK and other frameworks and cloud environments for deep learning have been created, further enabling its use. For specific applications such as image recognition, there are now web services that let users perform deep learning and even prediction without programming.

The use of deep learning is rapidly becoming widespread. For example, farmers are using AI to learn images of cucumbers and distinguish ratings, and dermatologists are using AI to learn images of symptoms and diagnose skin cancer. In the future, the use of deep learning is expected to become even easier and commoditization will likely follow.

## Expanding AI Applications

AI applications are expanding in various fields by leveraging deep learning. AI is already used: in healthcare for diagnosis and drug discovery; in finance for stock trading and credit decisions; and in retail for marketing and customer service. In addition, AI technology supports our daily life in things we take for granted such as web search, path search and translation. Thus, AI will most likely spread to all fields in a natural way.

Robotic Process Automation (RPA), a system that lets digital robots operating with rule engines and AI automate white-collar tasks, is also becoming popular. RPA automates tasks without programming and it is currently used to perform rule-based automation of routine tasks. However, it is believed that advanced AI will be used to automate more sophisticated, non-routine tasks such as analysis and decision making in the future. Some predict*1 that more than 100 million global, full-time intellectual workers will be replaced by AI by 2025. This will likely contribute to the resolution of labor shortages.

AI is also being tried in research applications. For example, AI was able to reproduce the condition of a gas that needs complex control and that is difficult to reproduce. Using a method that would never occur to humans, it completed the task in a matter of an hour. Soon AI may advance rapidly in research-based fields such as science and physics, enabling dramatic progress.

## Further Evolution of AI Technology

AI is rapidly advancing in image and voice recognition. Moreover, it is still evolving in other areas. One of the evolving areas is the understanding of meaning. In addition to using text to explain the contents of an image, recent studies are actively trying to generate images based on text, thereby generating images that are close to the “meaning” of the text. Inter-exchangeability between language and image may mean that AI is getting close to understanding meaning.

Another area of evolution has to do with the issue that large amounts of teaching data are necessary for AI to learn. Humans have a natural ability to learn inductively based on events that are occurring, and to identify an object after it has been taught only once. For realization to mimic this ability, a technology called deep reinforcement learning is attracting attention. Reinforcement learning is the autonomous learning of the action to take next or the condition that needs to exist based on experience. Deep

reinforcement learning combines reinforcement learning and deep learning. With this technology, there is no need to provide teaching data necessary for machine learning in advance. All that is required is to set up the desired actions and conditions. AI will then use repeated trial and error to learn the task. This technology is already used in AlphaGo, an AI Go playing machine that surprised the world by beating a professional Go player in 2016, in self-driving cars and in robots used in factories.

Many studies are underway to make machine learning possible based on small amounts of teaching data for tasks to which reinforcement learning cannot be applied. The fundamental concept of this is called transfer learning, where the knowledge acquired when learning one task is applied to the learning of another, streamlining the learning process. For example, in an image categorization task with limited amounts of data, teaching just one image from a category that AI had not yet learned enabled it to achieve an accuracy that was almost equivalent to a case where large amounts of data were taught. If this technology is implemented, AI is expected to learn things and events at a dramatic speed, furthering expanding its use.

## Importance of Knowledge and Technology of AI Utilization

While the development of deep learning is remarkable, it is not versatile. Therefore, it is critical to understand the advantages and disadvantages of deep learning before identifying its application areas. Under some circumstances, rule bases, probability/search models and other traditional algorithms may have to be selected. For example, in the world of chess humans cannot beat AI. On the other hand, in advanced chess collaboration between AI and a human attain better results. As a result, it is critical to identify the areas and the best method for such collaboration.

Even though there are developing technologies such as transfer learning, where small amounts of data enable learning, large amounts of learning data are still necessary to achieve a practical level of accuracy for AI in a new area. For this reason, it is necessary to determine how much learning data can be prepared in advance, and whether or not a system can be built that can perpetually accumulate data during operation based on feedback. In addition, pre-processing such as data cleansing, and the know-how on parameter tuning are important to achieve high accuracy. Machine learning has reached a point where a certain level of accuracy can be achieved. However, the knowledge and technology for utilizing AI will be a critical differentiator for companies in the future.

## Toward an AI that Contributes to Humans Further

The high accuracy achieved by deep learning, based on complex network structures similar to actual brain neurons, have become possible thanks to improvements in computer processing. At the same time, the process path to the answer has also become complex, making it difficult for humans to understand the judgments and reason for the end result. This is one of the challenges of deep learning. For instance, while looking at an image of an elephant, humans can recognize it as such, although they are probably not making a judgment based on logical reasoning. However, if they are asked for the reason they have decided the image is an elephant, they site reasons such as its long trunk and huge ears. Thus, similar to humans being able to explain the reason after the fact, AI may be able to provide accurate explanations for the process path to the decision. A project*2 is underway that aims to enable the explanation of the basis of output results. If AI can acquire the ability to explain its judgment and reasoning in the future, it will be easier to improve accuracy and apply it to cases where human lives are involved, such as in self-driving cars.

Discussions are also underway on the singularity of AI's abilities to exceed those of humans. Many non-profit organizations have been established with the purpose of: keeping AI from becoming private and abused; developing AI to contribute to society; evaluating AI's impact and establishing development principles*3. Social, ethical and legal issues surrounding AI will need to be solved. These efforts will increase in importance in the future. Although AI is not yet fully developed, it is important to discuss its development and effective use as well as its risks now. Doing so will contribute to the benefits of using AI for humans, such as the resolution of labor shortages and energy issues.

*1 McKinsey Global Institute – "Disruptive technologies: Advances that will transform life, business and the global economy." May 2013
http://www.mckinsey.com/business-functions/digital-mckinsey/our-insights/disruptive-technologies

*2 Explainable Artificial Intelligence
http://www.darpa.mil/program/explainable-artificial-intelligence

*3 Open AI http://www.openai.com/
Partnership on AI http://www.partnershiponai.org/
AI Network Social Promotion Conference
http://www.soumu.go.jp/main_sosiki/kenkyu/ai_network/

# TT01 CASE STUDY

Technology Trend 01

The following eight technology trends are expected to have the biggest influence in the coming years.

## Automatic Generation of News Manuscripts Using Artificial Intelligence

The emergence of Deep Learning and improvements in computer calculation speed have accelerated the application of AI technology to business in order to streamline and automate tasks. The U.S. media industry is currently commercializing the technology to automatically generate news articles. The main method uses a predetermined number of template sentences, in which words and numbers are inserted to generate articles.

NTT DATA has launched proof-of-concepts that generate simple news forecast, using rules that humans use when they author documents. The rules are automatically derived from data with Deep Learning. These experiments include weather forecast messages from the Japan Meteorological Agency and some news manuscripts that newscasters read on the air. With the addition of NTT group's AI "corevo", a highly accurate Japanese language analysis technology, the AI generates more natural expressions. The evaluation of automatically generated weather forecast news articles were at a level that, with slight modification, would be consistent with the original message.

Use of this technology to generate articles will improve the speed of delivering sports news and disaster information. As a result, human reporters will no longer need to create a manuscript from scratch, allowing them to focus on other tasks that should be done manually. In addition, the technology can be applied to a variety of genres, such as financial and sports results, as long as data exists for AI earning. NTT DATA will be conducting more proof-of-concepts with this exciting Deep Learning and AI-based technology.

# TT 02

## Conversational Computing

**Technology Trend**

The following eight technology trends are expected to have the biggest influence in the coming years.

# Conversational Computing

*The advancement of voice recognition technology with enhanced context/emotion interpretation will make natural and seamless people-to-technology interactions available. Such intelligently interactive systems will change human behaviors, societal interactions, and decision making.*

## Expansion of Interactive Interfaces

It is now customary to see people talking to their smartphones. In fact, a personal voice assistant is being used in a variety of ways from checking the day's schedule and weather, to searching for nearby restaurants. It has even become commonplace to use text messages to inquire about, order, pay or send money via wire transfer for products. A recent survey*1 indicates that approximately 89% of users wish to use a messaging tool for business communication.

In addition to smartphones, voice assistant terminals installed in residences and offices are also becoming popular in both Europe and the USA. Since these terminals are always ready, just talking to them will start music, adjust air-conditioner temperatures and room lights or order products.

Behind the popularization of an interactive interface is the fact that, as smartphones have become popular, voice conversations with computers and the use of text chatting have taken root in our culture. The numbers of "active" global users, who use messaging apps at least once a month, are now over 3 billion. One of the factors may be that users have simply gotten tired of using apps. Users feel it is bothersome to install and learn to use each individual app. In fact, one in four users quit using a new app after using it only once. On the other hand, messaging tools use natural languages, which are familiar to humans, and users can immediately start using these tools irrespective of their IT literacy.

The advanced processing capability made possible through interaction technology, which was enabled by the development of AI in recent years, is also boosting the popularity of messaging tools. Chatbot, a program that uses AI to automate communication, is becoming particularly popular. Chatbots can provide a wide range of services from flight reservations to real estate suggestions. In addition, bank plans are in place for Chatbots to provide account balances and wire transfers and even financial plans based on usage patterns. Interactive services in coordination with AI will likely continue to increase in the future.

## Development of Conversation Support Technology

The development of deep learning technology in recent years has significantly increased the accuracy of recognizing images and other patterns. In October 2016, the error rate of voice recognition technology reached 5.9%, the equivalent to that of speech-to-text experts. In addition to voice recognition, lip reading with AI has achieved an accuracy of 46.8%, approximately four times as accurate as professional lip readers. This may enable users to interact with computers in situations where they are not able to speak or are in a distant location. Computers cannot only read, but are capable of varying tone and pausing speech depending on situations, producing voices close to human.

The use of the technology to recognize emotions from voice, expressions and text has also been spreading. For example, analysis of emotional changes in viewers enables the identification of effective scenes in commercials and differences in responses depending on countries and cultures. This technology is used widely in marketing. Call centers also use similar technology to support their customers with consideration for their emotions. Future uses of computers will expand from human assistance purposes to reading human emotions for direct interaction. For example, a computer reading anger in a user driving a car might talk to the user to calm him or her down.

Unlike humans, computers still cannot understand contextual meanings that hide behind words. For this reason, humans may feel stressed and disappointed about the interaction, and there may come a period of

disillusion with these technologies. In the near future, however, a context-understanding technology may be launched just as technologies such as voice and emotional recognition, and voice synthesis have been developed. These technologies, which support human interaction with computers, will enable more natural interaction as it more accurately understands the nuances of a conversation, including a user's intent and emotion. It is anticipated that this will further expand the use of interactive computing.

## Interactive Computing Innovates the World

Interactive computing in coordination with AI will result in ultimate personalization. Traditional personalization methods use past behaviors such as viewing and purchase histories. Using this method, products already purchased and related products in which the user is not even interested may often be presented. However, an interactive system can use conversations to interpret a user's intention, and respond accurately even to complex requests. Combined with information from sensors, this system can respond to a user's individual situation immediately. Personalized information will be available that defies comparison with what is used today, changing customer service, marketing and advertisement.

Conversation is the most natural communication tool used by humans. With a conversation-based interface, many future actions will be completed using interactive apps. Instead of opening a different app for each purpose, a system will probably appear in which a personal assistant app listens to user's requests, and then distributes the tasks to other apps and Chatbots based on content. As automatic responses from AI becomes possible, immediate and appropriate responses will be available 24/7, which will have an enormous impact on the relationship of individuals to society. The traditional individual-to-society connection mainly consisted of one-way information by companies, such as emails and online advertisements, and a temporary connection by telephone or direct visits to brick-and-mortar stores. With interactive computing, however, the company-to-individual, and individual-to-individual connections will become bidirectional and continual.

Interactive computing even has the potential of changing the means of decision making. Currently, users need to select relevant data out of an overwhelming amount of information and make decisions such as product purchases and travel arrangements. In interactive computing with AI, the information required is narrowed down step by step through interaction, leading to more natural decision making. Thus, not only will the process of decision making change, but satisfying and prompt decision making will also become possible.

## The Future of Interactive Computing

Interactive computing goes beyond a mere convenient interface based on speech. Accumulation of interaction histories and sensor information will increase the accuracy of behavior predictions based on the situation and preferences of the user. By forecasting users' intentions ahead of time and providing the necessary information from the system, interactive computing may well become a virtual enabler of human behaviors prior to individuals becoming aware of the desire for the behavior. For example, the system may be able to provide users with the information they need and data they need before they realize it.

The ultimate communication may not be via language, but the immediate and accurate transfer of intentions. Studies on a Brain Computer Interface, which reads human intentions using brain waves to control devices, are being actively pursued. As a result, it may become possible to control computers and vehicles by merely thinking about something. The ability to read complex thoughts may eliminate the problem of not being able to express one's thoughts in words, giving rise to interactions with no gap in communication.

Interactive computing is not merely an app on a smartphone or a PC. It will be installed as a standard feature in all kinds of devices, while making its way to becoming a new computing infrastructure. It will not be long before we can simply talk to a device to get any information or product, at any time and from anywhere, such as at a house, store or in a car.

*1 Global Mobile Messaging Consumer Report 2016
https://www.twilio.com/white-papers/global-mobile-messaging-consumer-report-2016

# TT02 CASE STUDY



## Combining Web-Based Customer Service and Omni-Channel Infrastructure

ITOCHU Corporation, BELLSYSTEM24 Holdings, Inc., and NTT DATA Corporation have formed a capital and business alliance to expand BPO business applying "OK SKY", a Web-based customer service interactive chat system developed by Solairo, Inc. with AI technology.

"OK SKY" delivers real-time, Web-based customer service via chat that is optimized for individual customers. The AI provides automatic primary assistance to a customer inquiry by identifying customer needs and assisting in the selection of proposed products and services. The AI then transfers the customer to an operator familiar with the products to supply more detailed support and for purchase decision-making. The system not only improves online purchase rates, but increases the number of customers visiting the Website and associated brick-and-mortar stores. It also allows a single communicator to serve seven to eight customers simultaneously.

BELLSYSTEM24 Holdings, Inc. will incorporate "OK SKY" within its contact center in order to integrate Solairo's ability to design sales processes together with their operational ability to expand their contract sales business. NTT DATA plans to increase sales to customers by uniting "OK SKY" with Omni-channel infrastructure*1. It will also coordinate with the NTT Group on AI-related technologies. ITOCHU Corporation will market "OK SKY" in China and to other Asian markets, where Web-based customer service is spreading rapidly. The companies together will strengthen their position and market share within the high-affinity BPO marketplace.

***1** An Omni-channel is an environment that integrates sales and logistics channels such as brick-and-mortar and online stores, enabling customers to shop whenever and wherever they wish.

# TT 03

## Environment-Aware Robotics

**Technology Trend**

The following eight technology trends are expected to have the biggest influence in the coming years.

# Environment-Aware Robotics

*Advancements in perception technology for images and voice is enabling robots to acquire enhanced environmental awareness, providing opportunities to exploit its use within products such as self-driving cars and drones. These higher-level operational capabilities will transform the industrial structure.*

## Development of Technologies for Recognizing the External World

It is safe to say that robots have better eyesight than humans do. One reason for this is that Deep Learning technology has increased the accuracy of image recognition year after year. This was proven at the 2016 ImageNet Large Scale Visual Recognition Challenge (ILSVC), in which a robot identified the name of an object in an image with 97.0% accuracy, as compared to the 94.9% for humans. In addition, SLAM*[1], a technology that simultaneously estimates a robot's own location and creates a map of its surroundings based on information from a camera and a sensor, has enabled highly accurate capture of a 3D space. Yet another new technology allows the capture of a space with only a smartphone using a monocular camera, which will enable the effortless creation of indoor 3D maps. This technology will likely become widespread in many places like commercial facilities, warehouses and factories.

Voice recognition has also become more accurate, achieving human level and giving robots effective ears as well as eyes. Finally, robots can recognize things that humans cannot, such as ultrasonic waves, infrared light and magnetism; this capability is inherent to machines. It is anticipated that robots that possess the perceptual aptitude of humans in addition to other capabilities will rapidly expand their range of application.

As the ability of spatial recognition improves, robotic contests, whose purpose is to enhance the functionality and performance of robots, are on the rise. For example, at an Amazon Picking Challenge, robots compete on their ability to place products on shelves and remove them, while at a RoboCup, robots compete on rescue of humans on a soccer field or disaster site. In addition, at the inaugural event of a robotic car race called the DARPA Grand Challenge in 2004, none of the participants could make the finish line. However, five cars completed the race in 2005, building the foundation for the self-driving technology of today.

## Lower Costs and Evolution of Hardware that Supports Robots

LIDAR, a sensor that uses light and recognizes 3D spaces, can measure particle sizes smaller than radio radars. Because it can even recognize the shape and moving speed of an object, it is receiving special attention as the potential "eye" of a self-driving car. Although LIDAR is costly today, manufacturers are targeting a cost of $100 or less in five years. Efforts are also underway to install LIDAR's sensor in a single microchip with a potential price of only $10. This type of LIDAR would be installable in many devices, and its use would quickly spread to robots and home electronics. Concurrent with this, an effort to achieve a self-driving function without sensors such as LIDAR is underway using improved camera performance and AI to recognize objects and measure distances. Either of these evolving technologies may become the optimal choice as robots' eyes.

The growing field of Biomimetics models the superior functions and structures that living organisms have attained, and applies these results to technological development. Biomimetics is helping to further develops robotics. For example, robots in which a tactile sensor that models human pain are now able to feel discomfort upon impact and to act to avoid the impact. This will likely enable the reliable use of robots in situations where they need to work closely with humans.

## Popularization of Robots, Mainly Self-Driving Cars

A self-driving car may be considered a robot that operates autonomously while recognizing its surroundings. It is also the robot that is garnering the most attention nowadays. IT companies have entered the self-driving car race in addition to automobile manufactures, accelerating the trend toward mergers and acquisitions. The year 2016 also saw proof-of-concepts of self-driving buses and experimental services by self-driving taxis on public streets. In addition, the world's first self-driving delivery truck ran an autonomous trial run on a 190 km stretch of expressway. Importantly, the arrival of deliveries by self-driving trucks is expected to reduce significantly the current truck driver shortage, which continues to increase due to the rapid expansion of e-commerce. It will take time before a completely autonomous car, which does not need human intervention under any conditions, emerges. However, autonomous driving is already available under specific circumstances.

Drones are being utilized for a wide variety of business purposes including surveying, 3D map creation, inspections, security, search and rescue, investigations, deliveries and for entertainment purposes. Drones can fly over difficult locations at low costs and identify accurate spatial information of a location. As a result, they hold the potential to increase efficiency and provide new services in an incomparable way.

Robots are also spreading their working arena to commercial facilities, households and public spaces. For example, there are now robots that use a camera and a sensor to patrol the product display shelves to find out-of-stock products, wrong product placements and messy displays, raising the potential for significantly reducing labor. To assist in everyday life, there are now self-driving vacuum cleaners and communication robots, as well as those that suggest recipes using ingredients stored in the refrigerator, and even those that can cook.

## Advanced Tasks and Mass Customization

In addition to automating simple tasks that humans have been performing in the past, even advanced tasks that only experts were able to perform are now being automated. For example, agricultural applications include a drone equipped with a camera and sensor that sprays pesticide only over areas where pests inhabit, or that adjusts the amount of fertilizer depending on the condition of crop growth in a particular area. This drone can perform tasks with a precision far higher than that of humans, and such automation can result in significant savings on pesticides and fertilizers.

Individual customization of products has been difficult to bring to fruition due to cost-related problems. However, in the future autonomous factories may emerge where, based on data acquired from manufacturing machines and sensors as well as from sales and material procurement, a robot autonomously determines the necessary materials, most efficient manufacturing process and methods for coordinating with other machines; thus automatically changing production lines. As a result, mass customization may become a reality.

## Economic Impact of Robot Popularization

The global robot-related market is predicted to more than double from 91.5 million dollars in 2016 to 188 million dollars in 2020*2, with the competition of functions and pricing of robots increasing in the future.

In particular, the automobile industry will very likely reach a significant tipping point. During the development phase of self-driving technology, the car's driving performance is the major focus. However, once a fully automatic self-driving car is completed, driving performance is assumed, and the transportation experience itself will become the determining factor. This means that the car industry will likely shift from the traditional form of selling things to that of selling experiences and services. The definition of customers will also change from people who wish to own cars to all people who have transportation needs.

## Discussions on the Required Reform of the Legal System

High-performance robots will also bring higher risks of injuring humans and infringing on privacy. Accordingly, the future development of robots will require the resolution of these problems including new legislation.

Looking at the mid- to-long-term future, discussions are currently underway to impose a robot tax on owners under the assumption that robots are electronic humans. In addition, the introduction of basic income grants to all citizens in order to maintain a minimum standard of living has been much discussed, with experiments starting in Finland and San Francisco. These discussions are assuming that social structures will significantly change with robots and AI replacing people at jobs. However, as with computers, new professions will emerge but different skills will be required. In addition to systemic adjustments in taxes and life security, the education programs needed to fill this skill gap will become vital in the future.

---

***1** The official name is Simultaneous Localization and Mapping.

***2** Worldwide Semiannual Commercial Robotics Spending Guide, IDCGuide, IDC

# TT03 CASE STUDY



## Development of an Open Platform for Intelligent Manufacturing

The NTT Group is collaborating with partners through ICT. FANUC CORPORATION (“FANUC” hereafter), the Nippon Telegraph and Telephone Corporation (“NTT” hereafter), NTT Communications Corporation (“NTT Com” hereafter), and NTT DATA to utilize edge computing technology and ICT infrastructure to develop and launch the FANUC Intelligent Edge Link and Drive system (“the FIELD system”*1 hereafter).

The FIELD system is a platform that utilizes advanced machine learning to further improve the productivity and efficiency of manufacturing. This system combines AI and edge computing to enable distributed machine learning that allows for real-time processing of data collected from machines, and flexible and intelligent collaboration between machines. Connection of CNCs (computerized numerical control devices), robots, peripheral devices, and sensors to the FIELD system offers advanced analytics for optimizing manufacturing and production.

Utilizing NTT’s advanced technology, ICT infrastructure, and management solutions deployed worldwide by NTT Com, the group plans to establish and launch the FIELD system as well as its de facto standardization. In addition, NTT DATA will leverage its track record and know-how in application development and big data analysis for resolving challenges within factories which use the FIELD system.

***1** The FIELD system is FANUC CORPORATION’s IoT platform developed in collaboration with Cisco Systems (USA), Rockwell Automation (USA), Preferred Networks, Inc., and the NTT Group.

# TT 04

## Precision Life Science

**Technology Trend**

The following eight technology trends are expected to have the biggest influence in the coming years.

# Precision Life Science

*DNA Analysis, biosensors, and EHR continuously generate data related to individuals, accelerating the field of data-driven life sciences and enabling root cause analysis of genetics, personal habits, and environmental factors to aid in the treatment and preventive care of individuals.*

## Worldwide Analysis of Genomes

How much would average human life expectancy increase if cancer disappears from the world? This could become a reality if continuing progress continues to be made in genome research. In February 2016, the United States launched the National Cancer Moonshot, a project aimed at the eradication of cancer. As much as 1 billion dollars was budgeted for this national project, and one of its major goals is the collection and use of genome data, which is the information on entire genes. The objective of this project is the development of precision medicine, which provides prevention and optimal treatment for an individual based on their genome, living environment and Electronic Health Record.

The United States is not the only country that is developing precision medicine. In 2012, Great Britain contributed approximately 3 billion pounds to the launch of its 100,000 Genomes Project, a national effort to collect and analyze genome data for 100,000 people by the end of 2017. China also announced that it would invest 9.2 billion dollars in a similar 15-year research project.

## Development of Genetic Analysis and Biosensors

Fueling global analysis of genomes is the enhanced functionality and rapidly declining price of the next-generation sequencers. For example, the genome of a person can now be read for $1,000 or less. In fact, a do-it-yourself (DIY) kit for individuals is now available in the market.

The genes of microbiomes, which are microbial populations present within or on the surface of the human body, are also being researched. Microbiomes influence the human immune function and ease of nutritional intake, and are considered an important element for understanding health conditions. For example, medicines are being developed to treat intestinal diseases based on the microbiomes present in human intestines. The microbiome-related market is predicted to reach 899.1 million dollars by 2025*1.

Genetic analysis influence not only medical care, but agriculture, food and other industries. For instance, genes of hops, the main ingredient of beer, as well as coffee are now being analyzed to produce varieties that are easier to grow, resistant to pathogens or more bitter. In addition, microorganism soil analysis can determine which soil is most appropriate for specific crops.

The development of biosensors have also enabled the collection and analysis of important health data such as number of steps, heart rate, blood pressure, skin moisture and breathing. Emerging measurement devices include a sensor that prevents heatstroke by inferring thirst based on the moisture of the skin, and a wearable device that estimates the degree of stress based on the rate of breathing. Smartphones are also being used for blood pressure and pulse rate measurement, eyesight and hearing examination and ultrasonography. Consequently, it will not be long before users can more easily manage our own health without going to the hospital.

## AI Accelerates Life Science

AI-assisted drug development is similarly attracting great attention. Generally, a period of more than 10 years, and R&D expense in excess of $1 billion are required to develop a new drug. More than 100,000 proteins exist that can be candidates for the causes of diseases. The number of combinations of chemical compounds working in these proteins runs upwards of the 60th power of 10. As a result, it takes two to three years just to discover a new drug candidate. In addition, only 1% of

new drug candidates will be proven effective, leading to even more time needed for non-clinical and clinical tests. For this reason, drug prices remain high. However, if AI learns the data on the molecular structures of existing drugs and their actions, it can then discover the new chemical compound candidates that can act on the proteins that lead to diseases. In one dramatic example, a new drug candidate was discovered in only one day by utilizing AI. If drug candidates that cause harmful side effects are eliminated, and new effective drugs can be discovered at a higher probability rate, consumers can expect significantly shorter drug development cycles and lower costs.

Use of AI is spreading to medical practice. AI can now use treatment data accumulated in the past to assist in differential diagnosis, where symptoms are identified based on an interview. Disease names are enumerated in order of high to low probability with required treatment details. Oversights can be avoided this way regardless of the experience of the physician. In February 2016, DeepMind, a subsidiary of Google known for developing an AI go application that beats top professional go players, launched DeepMind Health with the purpose of developing AI that specializes in the medical field. Coordinating with hospitals, the company has already developed applications for physicians and nurses. After learning past cases, the AI analyzes a patient's condition to determine acute kidney damage that requires urgent response. In addition, efforts are ongoing to use AI to detect signs of eye disease by reviewing past diagnostic images, symptoms and treatment details.

## Expansion of Individualized Medical Treatments and Healthcare

Improvement of genetic analysis and AI technology is steadily enabling more individualized medical treatments. For example, it is now possible in the treatment of breast and lung cancer to select the therapeutic drugs that are most appropriate for the genetic structure of the patient. Genetic analysis can also detect an individual's future physical tendencies such as a higher possibility of cancer, thereby enabling preventive measures. This popular trend is significantly contributing to medical care. However, one important issue is the disparity in the amounts of analyzed genome data depending on nations and races. A majority of genome data comes from the United States, Europe and Japan. The data on East Indians, who account for approximately 20% of the world population, is estimated to account for only 0.2%. This means that drugs and treatment methods based on the current genetic data may not work for many people. It will be necessary to conduct comparison and analysis using groups of many different backgrounds. To do this, the cost of genetic analysis will need to drop further, and governments must lead efforts to build systems for genome data accumulation.

## From Treatment to Prevention

We are now entering a prevention-centered world. Cookie-cutter treatments are no longer adequate. Disease prevention must become more precise and appropriate for each individual. Compound analysis of an individual's genetic information, vital sign sensor data and lifestyle will enable the prediction of risk factors that increase the probability of falling ill, as well as appropriate preventive measures prior to the appearance of symptoms. In this way, the focus of medical care is transitioning from the treatment of symptoms to the prevention of causes. A number of such services have already emerged. A prime example of this is the delivery of food that is optimal for an individual based on the results of his or her genetic and blood tests. An aging world population is expected to result in skyrocketing medical costs. However, if an individual's health can be enhanced through preventive measure, a significant reduction in medical costs be realized.

What kind of future will await us if individualized prevention and treatment become a reality? The average life expectancy will increase, and the day may come when many 90-year-old people remain working and in good health. Although the average life expectancy of humans has increased, the individual longevity record has not changed since 1997 when a female died at age 122. Further technological innovation may be required to enable humans to reach a more advanced age.

*1 http://www.marketsandmarkets.com/PressReleases/human-microbiome.asp

# **TT04** CASE STUDY



## Smart Alert Preventing Complications in Intensive Care Units


Medical studies have reported that early medical intervention before the occurrence of complications leads to a more effective recovery. To enable this, NTT DATA and the everis Group (“everis” hereafter), an NTT DATA affiliate in Spain, developed Smart Alert Solution. This solution predicts the risks of complications occurring to the patient based on the accumulated chronological data of the patient’s vital signs, and reports the risk scores and information necessary for diagnosis to the doctor or nurse. Virgen del Rocío University Hospital in Spain is the first hospital to verify the effectiveness of the system in assisting Doctors’ decision-making. Officials at the hospital believe that detecting risks of complications just two hours prior to occurrence will facilitate more appropriate treatment, shortening patient recovery time.

Specific complications that this solution is targeting are : (1) septic shock; (2) episode of rapid drop in blood pressure; and (3) hypoxemia, all of which may be fatal to ICU patients. AI is being used to build a system that predicts risks for these complications. An AI prediction model is being built based on public ICU data called MIMIC II*1. The patients’ data will then be processed using distributed streams on NTT DATA’s OSS big data infrastructure to enable the real-time prediction of complication risks.

***1** MIMIC II is a database on ICU patient treatments. It anonymizes data accumulated at the Beth Israel Deaconess Medical Center in the US.

# TT 05

## Synthetic Reality

**Technology Trend**

The following eight technology trends are expected to have the biggest influence in the coming years.

# Synthetic Reality

*With the rapid evolution and diffusion of virtual reality (VR) and augmented reality (AR) devices, the digital and real worlds are being further integrated and expanded. Human perception will become synthesized within new 3D spaces, allowing the sharing of knowledge and distributed experiences.*

## Rapid Evolution and Diffusion of VR Devices

Head-mounted displays, which provide immersion experiences in virtual space, finally reached full-scale adoption in 2016. The technology began when different companies sought to replace human visual perception with that of virtual reality popularizing the VR-HMD (head-mounted display) devices in approximately 2010. These efforts coincided with the time when VR-HMD technologies became available at affordable prices. Typical units consist of a computer that generates virtual 3D-space images in real time, a position-tracking technology that tracks human movements and a small display that enables high-definition. With prices 1/10th of those in the past, these products are rapidly becoming popular in many households.

## Immersion Experience Generated by VR Devices

The experience of replacing human eyesight with a virtual space is a sensation that humans have never before experienced. It is completely different from that of 3D TV, where the audience passively watch images popping out of the screen. With a VR device, eyesight is completely covered by a virtual space. A movement of the user's neck triggers the rendering of additional virtual space, which rapidly heightens the sense of immersion. In addition, moving the face closer makes an image look larger.

Successful VR-HMDs have inspired great anticipation for the development of a device that replaces tactile and other human senses with virtual reality. However, a method to re-create the sensation of touching an object, lifting it to feel its weight and feeling its movement or temperature as well as other sensations is still in development. An enormous technological barrier needs to be overcome before minute finger movements can be sensed together with appropriate tactile sensations provided as a response. To accomplish this, the development of an intuitive controller that minimizes the user's recognition of isolation from the real world, and a combination of a visual effects device and a suit that enhances sensory experiences, will be required.

## Pioneering Practical Applications of AR

The development of technologies called augmented reality (AR) and mixed reality (MR) also made significant progress during 2016. While VR means a complete replacement of the real-world view with a virtual reality, in AR the real world is blended together with virtual reality. Unlike VR, the goggles used in an AR HMD are transparent, letting the user see the real world. Virtual reality is pasted on real world space to create an intermingled world. Expected applications for this technology include learning, training and design. For example, the user can make a gigantic aircraft engine appear virtually in the room, observing its details at will by getting close to and into the object.

Many developers and forward-thinking companies have been focusing their investments on AR to speed its evolution. However, AR-HMDs currently have several technological obstacles and devices on the market are only for developers. One significant limitation is that the area viewable in virtual reality is still narrow, allowing virtual reality to blend with the real world only in a specific area. In spite of its present limitation, the superimposition of virtual reality to a human's natural eyesight may someday lead to a revolutionary UI to connect humans to information systems.

AR is also expected to generate new applications designed for the flat screen of a smartphone. An example of the many commercial uses of such applications include a situation where the user takes photos of his/

her room, and superimposes the image with that of a new piece of furniture prior to purchase. Although VR is used for product introductions and advertisements, more widespread adoption has been hindered by a psychological and physical resistance to wearing goggles. Smartphone AR can overcome this obstacle. Furthermore, AR may well be effective even under the current circumstances, where the development of a device that re-creates human senses, except for eyesight, is still in its infant stage. For example, delicate assembly work and training in medical practice require the use of actual tools or a full-sized model to repeat a task or operation while feeling a tactile sensation. AR can paste a patient body or a material that changes while being processed using a virtual reality. This enables effective and repeatable training that blends VR with a reality where an object such as a model and a tool can be physically touched.

## Improvement of Devices

An HMD interface that connects the user to a virtual space still has significant room for improvement. For example, an HMD needs to be connected to the base unit of a computer with an extremely high-speed calculation ability using a thick cable. For this reason, the user with an HMD cannot move about at will. An HMD should optimally be wireless. The next best thing would be for one without a base unit, which is being proposed. This HMD copies an idea from a smartphone processor that has both an advanced calculation ability and power saving. As the built-in lenses become thinner, the current situation, where a large, heavy, black box is worn in front of the face, will gradually improve. This technology will also be combined with the reproduction of images with a definition of over 8K, which exceeds the level recognizable by the retina, and with a response delay of 1 millisecond or less. In addition, with the release of a more accurate, innovative and outdoor-ready position-tracking technology, the so-called ”drunken” issue, caused by the gap between the position information detected by humans and the virtual space, the difficulty in outdoor use, and other limitations, will probably be mitigated. There is also a proposal to develop a system that enables collaboration without HMDs by pasting a virtual space in the physical space, with the ability to interact with it using projection mapping technology.

## Connecting with the 3D Space

As HMDs advance and improved interfaces are provided, people are expected to use virtual reality on a daily basis. An interface called VROS, which provides an integrated UI by combining different virtual spaces created by the computer, will emerge as well. This type of UI will probably blend the human-to-computer interactions with the real world, making us forget that it is a system UI.

However, the essence of the current fast-moving technical evolution may be a new exploration into the unknown world of human senses. Thanks to the diffusion of HMDs and the accompanying increase in the number of developers, as well as huge amounts of user feedback, in-depth knowledge about different human senses is being accumulated. For example, the size of an object identified by human eyesight has been assumed to change depending on the person’s attentiveness. This is a challenge for 3D content producers as they struggle to determine the display size of an object that makes humans feel “appropriate.” Some have reported that the actual-world action of catching a ball flying toward you is done with different movements or speed if the same action is presented through virtual reality. Knowledge such as this will not only be used in the recreation of human senses as a form of entertainment, but also in the creation of more natural interfaces, contributing to the improvement of the system-human relationship.

# TT05 CASE STUDY



## Applying the VR Technology to Sports Training Systems

In 2017, NTT DATA will release a VR (virtual reality) training system for professional baseball players. This is the world's first such system that has been developed with the assistance of a professional baseball team. Beginning in the 2017 season, RAKUTEN BASEBALL, INC. ("Rakuten Baseball" hereafter), which runs a professional baseball team called the Tohoku Rakuten Golden Eagles, will officially use this system. Under this VR system, a batter with a head-mounted display experiences a perception of a virtual batter's box and a ball thrown by a specific pitcher. This helps the batter improve performance in a game. "Sports First Person Perspective Synthesis Technology" developed by the NTT Media Intelligence Laboratories, enabled the building of this training system.

The first step was to synthesize a 3D ballpark space and a pitcher based on all-surrounding-angle video data. Next, Rakuten Baseball's own pitching data was accurately synthesized onto the 3D frame of the stadium. This enabled a re-creation of the player's standing position on the plate, which differs from player to player, and of the consistently accurate orbit of the ball as head position changes during a swing. This also allows a professional ball player, with a comfortable level of quality, repeated viewings of the pitcher's pitching action. It also lets the player learn the characteristics of an individual pitcher. As a result, players can use the system while updating its contents during a season, continuously improving the team's performance.

# TT 06

## Security for the IoT Era

**Technology Trend**

The following eight technology trends are expected to have the biggest influence in the coming years.

# Security for the IoT Era

*IoT devices have enhanced value by collecting more detailed and broader information, but have increased the risks from data breaches and large scale cyberattacks. While value associated with utilization is realized, it is now necessary to change the way we treat and protect data.*

## Escalating Cyberattacks

The spread and escalation of damage caused by a variety of cyberattacks know no boundaries. Today, the process that starts with these attacks and ends with funds recovery has been established as a business model. As criminal programs proliferate, more copycat offenders emerge, which encourages the techniques and tools to be continuously strengthened. This vicious cycle is accelerating.

Data breaches are steadily increasing and billions of individual user accounts are leaking. This information includes account data of online services, email addresses, associated passwords and sometimes secret questions and answers. This personal information is traded on the dark web, an Internet space accessible only by a special means. The damage is usually exposed two or three years after the fact. As a result, it is imperative to foster human resources that possess the skills to detect leak-seeking cyberattacks, deal with the ever-changing modus operandi and continue to protect information. Because it is virtually impossible to completely prevent attacks, the promptness of detection and recovery is vital. Efforts are underway to use technology to cut the affected section away from the network at a high speed, as well as for AI-assisted automatic protection.

Ransomware damage also continues to spread. Ransomware, also called ransom-demanding malware, encrypts infected data in a computer to make it unusable and demands ransom for decryption. It became common around 2013, and remains an effective means of attack. Cyberattackers purchase low-cost ransomware tools on the market, distribute them and wait to obtain ransom, repeating this “business.” It is difficult to control this crime except by improving the literacy of the public. The damage is expected to continue.

## IoT Worsens Cyber threat

In 2016, IoT was much discussed as an element that makes cyberattacks more serious. IoT devices, which include surveillance cameras, network devices, video recorders and electric meters, are powerless, stand-alone computers that are always connected to the Internet, and therefore exposed to the risk of information breaches and takeovers. These devices tend to run for a long time with a well-known initial password. Cyberattackers look for these “stray IoT” devices on a daily basis, and upon finding one exploit its vulnerability.

By the end of 2016, the number of stray IoTs in the world rose to hundreds of thousands. Cyberattackers organized them as a botnet, a group of bots working for Cyberattackers, and used them in the largest DDoS attacks in history. Huge amounts of packets were thrown onto specific websites in classic attacks disabling access to those sites, and resulting in enormous damages where multiple online services were suspended. A variety of similar attacks ensued. As with other cybercrimes, the IoT botnet is probably already established as a business and its use is on the rise.

The search for specific security measures to respond to IoT security threats is gathering speed. Using the computer security knowledge already established for IoT, it will probably be possible to eliminate IoT’s vulnerability. However, it is difficult to deal with the costs for such measures, combined with the lack of incentives for action. The imposition of liability to IoT device manufacturers, and authenticating and labeling these devices to prevent the emergence of stray IoTs, is currently under discussion. In Japan, an IoT security guideline was published and detailed measures are under review.

## Rapid Rise in the Quality and Quantity of Personal Data due to IoT

The value of secured data, especially personal data that should be protected and kept intact, will be changing. Traditional personal data includes data that users registered themselves, and those in which users' behaviors on the Internet were recorded. In the future, personal data will include behavioral and biological information of individuals that IoT devices capture from the physical world. As information continues to increase, it is assumed that a dramatic improvement of analytical ability will determine more detailed attributes of individuals. Even today, personal data on the Internet, such as clicking actions on a browser, postings on an SNS and products selected, are thoroughly collected. For example, the reason for the extremely accurate recommendations made about on-demand videos is the presence of a system that records and analyzes the user's viewing history, time, search history, pausing, fast-forwarding and even scrolling actions when selecting a video.

In the future, more information will be added to the data on individual behaviors that are observed by IoTs in the physical world. For example, a wearable device will obtain heart rate, blood pressure, running distance, speed and position information. A navigation system will collect the driving area, speed and vehicle condition. A security camera will catch images of a face, which is automatically identified and analyzed. A system records the rail stations where you get on and off a train, duration of a ride and the time it takes to change trains. As long as the user agrees, all this information will be attached to personal data, making personalization more robust.

Additional data created through estimation by AI based on huge amounts of combined personal information could bring negative results and disadvantages. For example, if estimated data such as health condition, healthy life expectancy and the possibility of illness in the future is created, all kinds of personalization could happen; from the presentation of certain drug advertisements to the control of advertisements soliciting for insurance policies or loans. This negative estimated data is produced before the individual realizes it, so it cannot be changed even if the information is wrong. This will cause disagreements if individuals have no way to alter the wrong information.

## The Status of Security and Information

As we face problems about treatment of widely-collected personal and estimated data, we can no longer avoid the key question of who owns the data. Currently, information about private citizens belongs to companies that collected and analyzed that information. As a result, many countries require the agreement of private parties on the collection of their information, and/or have legislation that governs the use of such information by third parties.

Trials are starting to build a data trading market that promotes the fee-based distribution of valuable information. Meanwhile, there are services that use anonymization technology to process the collected personal data into forms unidentifiable as any individuals, so that the data can be used in marketing without approval. The GDRP (EU General Data Protection Regulation), which aims to protect particularly critical personal data, is expected to go into effect in May 2018. The time has come for companies to build specific plans to adhere to this framework.

Large companies, who hold a dominant position on the Internet, particularly in the information distribution by smartphones, have already established a system where individuals who provided personal data can control their own information. In addition, in an attempt to acquire the information on IoT devices, they are expanding their service menus. They are also providing a console where users themselves can configure the opt-ins broken down by types of information, the viewing of collected information and the customization of advertisements. In other words, large companies are building a system to store information, while meeting the changes in the status of information.

It is possible to create an organization to counteract this oligopoly and to actively distribute information. However, it will be a long-term challenge to establish a business model where the new organization will acquire the trust needed to take care of large amounts of information and protect it. One of first ideas may be data exchange markets for open data collected by IoT devices, which a public organization owns. Accumulating such experiences will lead to the next stage of dealing with valuable information, such as personal information, which generates more profit.

# TT06 CASE STUDY

## The Method to Analyze Without Mutual Disclosure of Genome Data

With the advance of DNA sequencing technology, studies are underway worldwide to discover the relationship between disease information and genes, using methods such as a genome-wide association study (GWAS*1). Scientists are also conducting cross-sectional analyses of the genome data owned by multiple research institutions. However, genome data of an individual contains that individual's genetic information, which makes it highly sensitive and it requires very secure treatment. Privacy protection data mining, a technology that enables safe utilization of such information, offers a solution.

NTT is developing a secure multiparty computation technology, where both parties process encrypted data acquiring only the results of the processing without disclosing the specific data to each other. Recently, NTT and Tohoku University Tohoku Medical Megabank Organization ("ToMMo" hereafter) jointly developed a genome analysis method utilizing this privacy protection data mining technology. This method enables an accurate analysis of encrypted genome data owned by multiple research institutions without decoding or mutually disclosing the information itself. Specifically, NTT is responsible for the secure multiparty computation technology, while ToMMo handles the genome analysis technology. Use of this technology may accelerate further advances in healthcare by safely analyzing genome data brought by multiple research institutions.

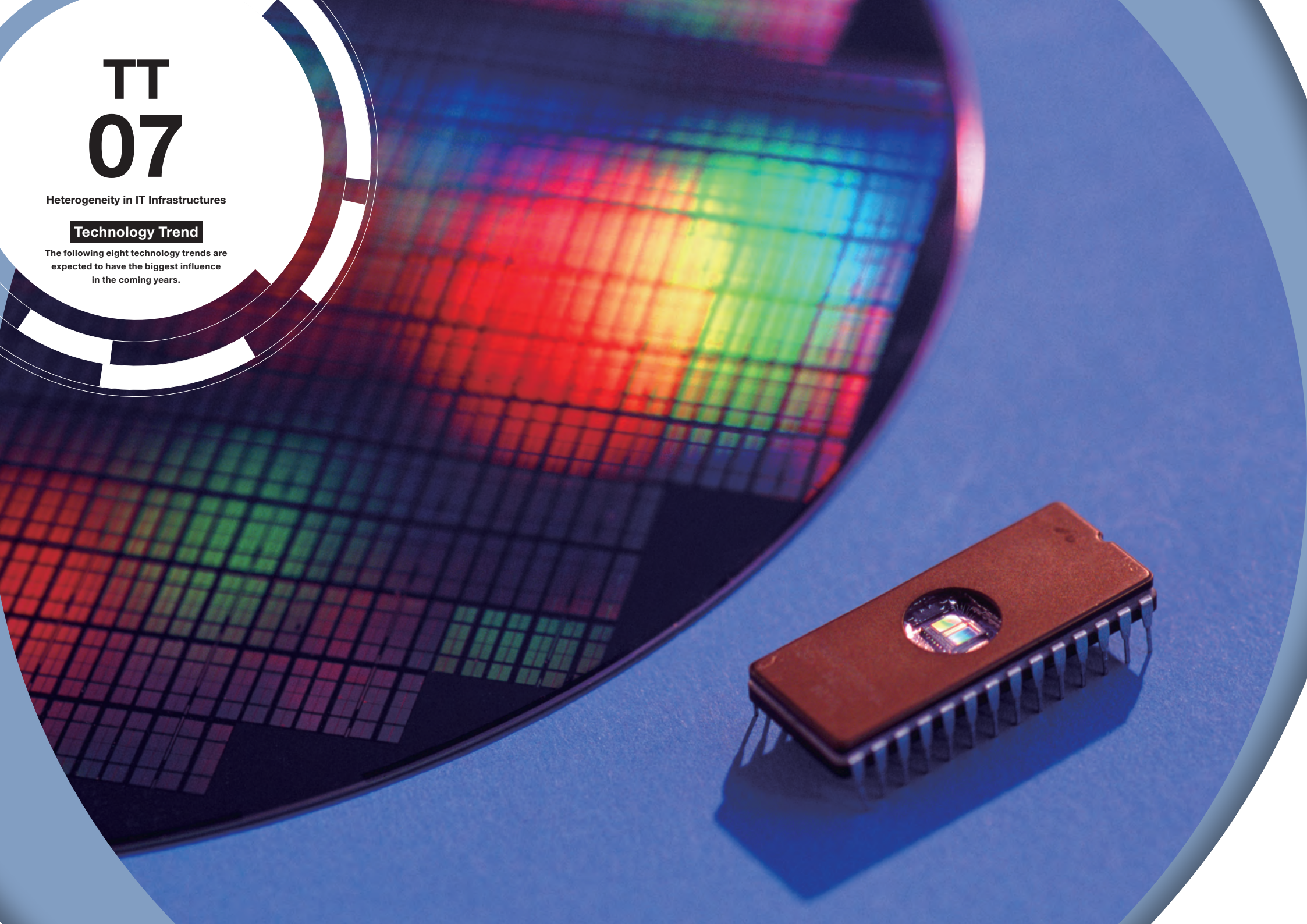
***1** Genome-wide association analysis is a method to statistically analyze the genetic frequency of the patient group and that of the control group throughout the entire genome to discover disease-related genes.

# TT 07

## Heterogeneity in IT Infrastructures

**Technology Trend**

The following eight technology trends are expected to have the biggest influence in the coming years.



# Heterogeneity in IT Infrastructures

*To supply the massive computing performance required for AI and IoT, new infrastructure is needed for both general use and specific purposes. Cloud services will rapidly enable such future flexible infrastructure.*

## The Change in the Leading Processor

The evolution of technologies is insatiable, demanding more and more calculation ability and processor power. In the field of AI, it is robust processor power that made Deep Learning break through and achieve commercialization. In self-driving cars, it is processor power that enables real-time identification of objects surrounding the car from four directions to determine the next operation of the steering wheel. It is processor power that, based on the movement of the user, allows real-time generation of high-definition images on a VR display. Finally, it is processor power that makes possible the more in-depth analysis of IoT-generated data for marketing purposes.

Processor manufacturers continue to compete in the development to meet the insatiable demand for advanced calculation ability. In the past, the calculation ability of the CPU, a multi-purpose processor, was constantly improved as the standard. Now processors that excel in parallel execution of many homogeneous processors have become the leader in calculation. Because trendy technologies of recent years required large-scale parallel processing, the adoption of the GPU (Graphics Processing Unit), has increased. In the AI area, the GPU achieved an efficiency rate that is 10 times higher than that of the CPU, making the GPU a de facto standard. In addition, the emergence of the GPU has coincided with the enhancement of software libraries, which utilize the GPU's characteristic features. As a result, the use of the GPU has been increasing from image processing, which was its original purpose, to advanced scientific computation. GPUs and processors with many cores that compete are used in devices ranked high in TOP500, which ranks supercomputers in the world. These parallel processors are also continuing to evolve, keeping their speed leadership for the foreseeable future.

## Diversifying Processors

In some cases, even the power of the GPU is not adequate, and a processor called the FPGA (Field-Programmable Gate Array) is being used. While the logic on regular processors is printed at the time of manufacture and cannot be changed, FPGA processors can be rewritten later and as many times as necessary. With FPGA, it is also possible to manufacture only a few units of processors specialized in specific applications. In the financial industry, an FPGA is used to perform high-speed algorithmic trading of stocks and currency exchange, changing the logic as needed and tuning it at the high-speed level of milliseconds to chase profit. Also in the competitive area of AI, dedicated logic is implemented on an increasing number of FPGAs in an attempt to achieve a speed and efficiency rate that exceed those of GPUs. In addition, efforts are underway to install the FPGA in several thousand units at a time to improve the overall processing ability of data centers.

A trend to use smartphone processors is also attracting attention. The processor of a smartphone uses multiple cores of different abilities to enable the phone to go to sleep or shut down in a short period of time, improving the efficiency of electric power usage. Low electric power usage and robust processing ability at an advanced level are spreading the use of smartphone processors to drones, connected cars and other IoT devices. In the future, the use of smartphone processors is expected to further streamline the operation of data centers.

Some companies design, manufacture and use their own dedicated processors for specific purposes. One of these companies developed their own processor that specializes in Deep Learning, and which is supporting the fast development of AI today. This specialized processor is currently installed in data centers to streamline the operation. It is a low-power-consuming processor

based on the knowledge that, even if the computation of floating-point arithmetic is less accurate than normal, it can be used in Deep Learning. The latest GPUs have also adopted this approach of lowering the computation accuracy of floating-point arithmetic for higher speed and improved efficiency. Deep Learning is a particularly competitive area, and it is driving increased competition in the development of specific-purpose processors.

The important characteristic of this new calculation ability is the development of software that utilizes the features of a processor. In particular, parallel processing would not exist without support by software. The difficulty level is high to develop this type of software, which makes it challenging for the processor to reach its potential. Processor manufacturers are enhancing software parts called libraries to make it easier for software developers to harness the processor power.

## Diversification of Architecture

Like processors, system architectures are also diversifying. Edge computing is an architecture that uses huge numbers of IoT devices in the field, i.e., edge, to make distributed processing more flexible and dynamic. When immediate processing is necessary in the field, or accumulation and compression of collected data is required, the edge processes these tasks while coordinating with the center as needed. Application to automatic operation is expected soon, and its development is ongoing along with the use of next-generation 5G networks.

The blockchain, a distributed ledger technology, is also attracting attention as one of the infrastructure technologies that support BitCoin. The blockchain enables sharing distributed data on the network while preventing data falsification. It is innovative in that it does not require the building of a robust and centralized database. Consequently, systematization of complex areas that have traditionally been impossible to do on a cost-effective basis, are now possible. In addition, funds transfer and payment uses, financing, contract management and the government's notarization service are undergoing proof-of-concept. BitCoin has been operating ever since its release, and new implementations of high quality blockchain technology are expected in the future.

## Utilization of Flexible Options

To make business ideas that constantly use new technologies come to fruition, it is essential to master the use of a system infrastructure that includes diversified and complicated processors and architectures. However, this kind of system infrastructure does not need to be owned. Clouds are taking the place of diversified infrastructures at a rapid pace. For example, users of the GPU, which is required for machine learning by AI, can select from available menus on the cloud. Even the special FPGA hardware is on clouds.

Mechanisms that never existed before, such as the blockchain, are now provided by SaaS. Whenever a new architecture appeared in the past, the barrier that faced an engineer was the preparation of an environment in which it operated. Now this barrier is considerably lower. There also exists new streamlining methods, such as server-less architectures, that only clouds can generate. As a result, it is now possible to launch a worldwide data processing service at low costs and without considering infrastructure preparation or performance design. It is also easier than before to migrate large amounts of data from an on premise environment to a cloud, to retrieve it or to migrate it to another cloud. Clouds enable the user to acquire any amount of data at any time, and to withdraw it at any time. In addition to being of great benefit to users, clouds bring flexible options in the use of system infrastructures to business.

## Changes Required of Users

Users need to acquire more knowledge and know-how to be able to handle more diversified and complicated infrastructures. Processors today achieve high speeds by cooperating with software. However, once a performance problem occurs, it is difficult to repair it by simply scaling up or scaling out. Although a GPU's software library reduces the burden to developers, its performance may be compromised without a tuning that considers the library features. Even though the FPGA is on clouds and operable on a browser, it is essential to have the necessary knowledge to implement the logic unique to this hardware. Because clouds present flexible and diversifying options, it is not easy to review the entire system lifecycle and select suitable cloud services, along with an option to leave a part of the system on premise. As a consequence, the development of human resources who can actively adapt to changes and today's technological trends, which go beyond the framework of traditional software and hardware and reexamine system infrastructure, is required.

# TT07 CASE STUDY



## Applying Blockchain Technology to Insurance Policies and Trade Finance

The blockchain is a decentralized network technology where network participants can share information with a secure anti-alteration capability. NTT DATA set our initial target for the blockchain in trade finance and computerized insurance policies, with proof-of-concepts underway.

First, ORIX Corporation, ORIX Bank Corporation, the Shizuoka Bank, Ltd., NTT DATA, and NTT DOCOMO Ventures, Inc. jointly conducted proof-of-concepts in trade finance. In trade finance, deal-making is more difficult due to long transport and administrative time, and the use of letters of credit. This type of trading also involves many different parties such as exporters, importers, and banks. To resolve these issues, the blockchain technology now offers a decentralized ledger function that enables sharing of a ledger, drastically shortening the administrative time from several days to several minutes. Invoices, bills of lading, and other shipping documents can also be shared simultaneously in a blockchain to streamline the entire trade operations

The Tokio Marine & Nichido Fire Insurance Co., Ltd. and NTT DATA are jointly conducting proof-of-concepts using this technology in insurance policies. As an overseas marine cargo insurance policy is transferred from the seller to the buyer, it circulates internationally via paper to banks and other trade-related parties. It is anticipated that digitization of insurance policies through the use of the blockchain technology and importation of the information in the letters of credit and bills of lading residing within the blockchain, will increase security, reduce labor and shipping costs.

# TT 08

Experience Design Innovation

## Technology Trend

**The following eight technology trends are expected to have the biggest influence in the coming years.**

# Experience Design Innovation

*Development of the API economy and UX design are simplifying the creation and continuous evolution of innovative services. Propagation of IoT will drastically change interactions between human and systems resulting in more natural and freer user experiences.*

## Penetration of API Economy

Recent years have seen a significant change in the way services are generated. Ideas have been transformed into businesses at an extremely fast pace. The company that grew rapidly by being the first to market a ride share service, where a private car and its owner become a taxi, is a prime example to show how fast an idea can become a business. At the onset, these companies outsourced everything except for their smartphone app and related matters. They utilized existing services that they did not own even for elements that normally make up the core of a service, such as a navigation system, credit card payment service and telephone and messaging services. It is the API (Application Programming Interface) cooperation that made this possible. The API economy, which is this simple linkage of existing services via the Internet, enables a fast launch of a service. In addition, as the ride share service earned a good reputation and became recognized as a stable service, it is in turn used by other services through API cooperation. For example, the drive share service is now embedded as a button on hotel and restaurant websites, and offers a one-click, transportation linkage service to hotel guests and restaurant customers.

Using IT to launch a business and to gather a variety of elements necessary for that business, is now a common practice. Even small startups can build a new business by combining existing services. Companies can combine services by calling them via the Internet, and release their products with a short lead time, testing its value in the real world. The speed of launching a business is not the only thing that has changed. The subsequent, continuous improvement of User Experience (UX) is also accelerating thanks to the use of IT. Through API cooperation, the ideal UX design process, which constantly improves services throughout the lifecycle, including the operation phase, is now being realized faster and easier.

## The API Economy Accelerating on IoT Platforms

The spread of IoT upgrades the way business is generated to the next level. The IoT platforms that companies now provide combine an integrated management system that includes networks that correspond with each of the various IoT devices; a server-side system that links with these devices; and a system for processing and analyzing the collected information. For example, these platforms manage IoT devices installed in manufacturing machines or in vehicles and collect information on operational status, fuel consumption and parts status. By analyzing this huge amount of information, abnormality can be detected in devices, and the appropriate time for replacement can be determined. In some cases, labor status of workers is collected and tallied to be used in balancing the workload.

A move to make IoT platforms open is also expected. Companies keep many of the matters regarding their IoT platform proprietary. The streamlining effect achieved by installing an IoT platform and using the information acquired from it definitely stays within a company. In the future, new businesses will be generated by disclosing the information collected on the IoT platform and the bundles of IoT devices that the companies manage, thereby offering them to the outside world. Efforts being attempted by some companies assume that electric power usage data is collected from households that gave consent, analyzed and used in cross-industrial marketing.

At the household appliances trade show held in January 2017, the potential of the IoT platform was shown. As many as 700 IoT products were exhibited with implemented API cooperation to a cloud-based voice interaction interface. For example, the smart speaker,

which uses natural conversations to order products and services via the Internet, is now a popular product that ships 5 million units per year in North America. The voice interaction interface, which has flooded households and has accumulated an adequate track record in voice recognition, is provided as an API cooperation service. By linking household appliances such as refrigerators and vacuum cleaners to existing IoT devices such as automobiles, these household appliances have uniformly been upgraded to voice-supported services. Furthermore, this voice conversation interface is already linked to 4,000 services, all types of product sales and food delivery reservations, lodging reservations and taxi calls. There is a high probability that these services will link with other services in the future to create platforms that provide increasingly streamlined customer experiences.

## The UX Innovation by IT

The service industry has entered the stage where users can pursue more natural UX, thanks to the power of IT. The rapid evolution of AI has made possible the voice recognition interface, space recognition by computer vision and the integration of actual and virtual spaces by AR. The latest IT technologies also have a potential for generating entirely new UX. Of particular note is the "supermarket without cashiers," which was publicly demonstrated by a large North American e-commerce company. This is an example where IT technology completely rewrote the traditional UX. This store contains many IoT devices, cameras and sensors. Customers are authenticated by waving a barcode over the gate when entering the store and their movements are constantly tracked by IoT devices. This tracking also identifies the motion of hands stretching toward a shelf to get a product, hesitation and even returning the product to the shelf. Customers simply get what they need and exit the store. Smartphones then show the items selected and complete the payment. The UX is that you simply get what you need and go home. This may well be a new UX format that is difficult to imagine for someone who is used to an established supermarket.

## The UX Innovation Continues

The UX innovation will probably affect IT technology itself. For example, the operation of a smartphone, which is now a starting point for different kinds of service, will be innovated. Is it really intuitive to stare at a screen full of icons, which act as metaphors for the actual world, select the icon for the target operation and touch it? Icons (i.e., apps) are independent of each other, and their linkage is thin and even information sharing is difficult. A person who has just started to touch a smartphone has a long learning curve until he or she can use it smoothly. This fact alone may prove that a smartphone is an incomplete interface. Instead of depending on the flat screen of a smartphone, it may be necessary to make use of VR, AR, and projection mapping for a more complete interface. Use of natural human gestures is also possible. However, the fact that humans must actively talk to a machine to interact may be unnatural in itself. A voice conversation interface that does not recognize that it is talking to person without certain keywords is not natural. Current interfaces are triggered by unnatural behaviors that are far from intuitive ones such as looking, speaking, and grabbing movements. The IT interface is waiting for the innovation of the UX.

The UX innovation by IT is different from unregulated installation of technologies. Businesses born on the Internet have the dynamism that something is worth trying if it is technically feasible. However, such dynamism may decline after negative user feedback. For example, the supermarket without cashiers could adopt all technologies already used by Internet stores. The minute the customer picks up a product, an advertisement using AR might come on, informing the customer of the 2-for-1 deal. In addition, user reviews of that product might be listed. For a customer who always hesitates when reaching for a cupcake, it may be possible to create a mechanism where music is played that heightens the customer's appetite to buy while appropriate images are shown. Are these ideas really appropriate? If a true UX cycle is achieved that repeats improvement based on user feedback, these ideas could be replaced with more appropriate mechanisms. It is assumed that continuous and serious UX innovation with users in mind is the correct collaborative design for both humans and IT.

# TT08 CASE STUDY



## Interaction Control Technology that Collaborates with Robots and Devices

NTT is developing a technology so that users can take action through the collaboration of sensors, robots, and other devices. "R-env: Rembu" is a cloud environment where the development, debugging, and operation of a device coordination service, which combines robots, sensors, gadgets, and Web services, can be performed on a single browser.

"R-env: Rembu" can be connected to a wide variety of devices, including signage, robots, smart devices, and sensors. Users can easily develop a device coordination service on the GUI screen of a browser by creating a state transition diagram that summarizes the action of each device connected to "R-env: Rembu", and the condition for moving to the next action. These are the major features of the system. Set to the run state, services developed on the GUI continue to operate even after closing the browser. By running multiple state transition diagrams in parallel or re-using them, complex device coordination services can also easily be created. When adding a new device, users need to send the required JSON format first through WebSocket, a computer communications protocol. The new device is then recognized and registered for integration into the service.

NTT has been providing opportunities to experience this system through the "R-env: Rembu" Innovation Hub at hackathons, and field and business trials, as well as other events. Some examples include development experience events to watch robot and disaster prevention robot services, robot x IoT solution services, and conversation robot services.

# *Looking ahead : Technology trends driving business innovation.*

*More than ever, the importance of applying innovative technologies for sustainable growth is accelerating.*

*NTT DATA Technology Foresight presents information society and technology trends.*

*By analyzing major issues within politics, the economy, society and technology, we hope to deliver business innovation for our clients and society.*

Tsuyoshi Kitani

*Executive Vice President & Director*
*Technology and Innovation General Headquarters*
*System Engineering Headquarters*

NTT DATA
Technology
Foresight


**NTT DATA Corporation**

Toyosu Center Bldg. Annex, 3-9, Toyosu 3-chome, Koto-ku, Tokyo 135-8671, Japan

**NTT DATA Technology Foresight**

Strategy Development Section

Research and Development Headquarters

**http://www.nttdata.com/global/en/insights/foresight/**


Contact NTT DATA Technology Foresight team if you are interested in knowing more about any of these trends.