

NTT DATA Technology Foresight 2020



Looking ahead:

Technology trends driving business innovation.

Digitization has positioned society at the beginning of the next social revolution. The constant innovation in technology will continue to drive social structures toward the future, transforming existing business models and bringing them to new levels.

To make optimal business decisions, it is critical for leaders to identify and understand future changes and to determine the best course for sustainability.

At NTT DATA, we continually investigate advanced technologies and social trends that we believe will impact businesses over the next three to ten years, and we publish these findings on an annual basis for the benefit of our clients.

Information Society Trends

Societal trends impacting people and businesses



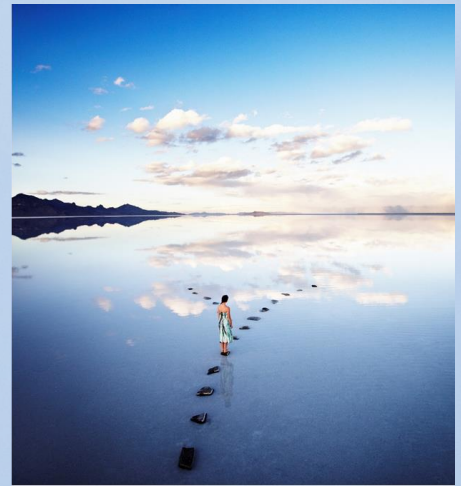
IST01

Individual-Centered Design



IST02

Expand Beyond Borders



IST03

Forge New Norms



Information Society Trend 01

Individual-Centered Design

The power of the individual continues to grow. Technological advancements have increased our ability to analyze people and objects with extreme precision, enabling personalization of services, products and organizations. Continuous and rapid improvement of human-centered design that deeply focuses on the individual is imperative to expand future business opportunities and improve society.

Advancements in technology and its social permeation, as typified by the internet, have garnered various types of power and influence by individuals. Delivery of messages by people through social networks has connected society to the extent that it has had unprecedented political and social impact. In an age where technology helps create environments amenable to individual-centered activities, new-skill acquisition and increased expertise, the broadening power of the individual may be a natural consequence.

Advancements in cutting-edge technologies, especially those in AI, are creating new flows of information and the informatization of things is becoming a reality. As a result, we can now understand individual intentions more clearly, capturing changes at shorter time intervals and identifying event flows in more detailed ways. This trend also accelerates the speed at which thoughts and actions support individual-centered activities.

Personalization has become an important priority. Shifting our focus to the individual's perspective results in new ideas and challenges, which in turn leads to

accelerated innovation. The use of AI lets us extract personal attributes and positions individuals as critical resources to spearhead social and business development. If we can identify individual attributes and special skills and find opportunities to leverage this expertise, individuals will increase their sense of achievement, mission and happiness. In the age of increased individual power, individual-centered design becomes critical to develop society and expand business. Use of technologies to assist in this type of design are now being pursued rapidly.



Information Society Trend 02

Expand Beyond Borders

Territorial and digital/physical limitations are fading. The evolution of technology enables businesses to transcend boundaries and delve into untouched frontiers, crossing global and conventional borders. The relentless leveraging of technology and innovation to break down barriers will become a driving force of economic growth.

From the end of the 20th century and into the 21st century, technology has become part of a core growth engine for the economy. IT infrastructure, together with software development, has continued an exponential evolution, creating complex functions and enabling the rapid expansion of businesses. Incorporation of such evolutionary technology and growth abilities to business will be the essential driver of future economic development.

Technology is also bringing about significant societal change, expanding the world in unanticipated ways. Business has now gone beyond borders, bringing services to all countries and regions and making industrial boundaries inconsequential.

Moreover, technology is contributing to new frontiers where humans have not reached. For example, network connection services via artificial satellites are providing environments where business can be deployed at a truly global scale. This in turn enables the development of new customers and markets as well as the expansion of production bases and supply chains. Technology also

contributes to understanding the mystery of life by further clarifying the structures of the human body such as genes, proteins and the brain itself. Such efforts may someday eliminate the physical, physiological and temporal limitations of humans. If this happens, humans may go beyond the traditional limitations of their abilities resulting in enhanced health, prolonged lifespan, more detailed and long-term memories and increased productivity. Thus, technology will likely become an important element in expanding what we know now as our traditional world.

As everything becomes more digitalized as part of this global expansion process, near-perfect decision-making may become possible. If people, nature and all other things that exist in the physical world can be digitally replicated for simulation, it will enable risk-free analysis of countless possibilities and strategies prior to implementation. As a result, superior decision-making will likely be the driving force of future economic growth.



Information Society Trend 03

Forge New Norms

Technology is permeating society at an unprecedented rate rendering traditional norms obsolete. Conventional standards must be transformed to keep pace with innovation. It is essential to forge, shape and nurture new norms that can adapt rapidly to changes in societal and business environments to achieve a sustainable society.

Technology is expanding business by providing services best suited for individuals, enhancing health, solving global issues and delivering countless other benefits. It is also creating a world in which social activity is more accessible, supporting personal growth and a sense of purpose in life. However, amid rapid social changes triggered by advancements in technology, unforeseen challenges are arising that cannot be solved based on traditional norms and values.

While the internet has resulted in a world in which everyone can share knowledge, it has also created a society where we cannot ignore the reality of inequalities resulting from poverty, starvation and lack of education. For example, discrimination can be reinforced due to bias in learning data and false information shared via fake videos. Over-universalization of technology may also create a social divide as a result of a disparity in technological literacy. As the definition of society itself changes to one that presupposes the use of technology, enhancement of technological literacy will become a prominent social issue.

In recent years, technological inventions have dramatically shortened actual time-to-market. This is resulting in a delay in establishing the rules and norms required to apply a specific technology to society, the evaluation of its impact on everyday life and the development of ways to solve the expected issues. We need a way to shorten the time lag between technological advancements and the establishment of associated norms to solve issues arising during the cycle time.

Now is the time for a convergence of global wisdom as we are at the vortex of technological change. To make our future society sustainable, we must resolve potential issues that result from advancements in technology. Should we impose restrictions or defer to ethical solutions? We must solve these global, social challenges to avoid a potential breakdown of society. Exploration of new norms with the addition of technology, coupled with coordinated efforts between technology makers and users, will be necessary to ensure the sustainability of humankind.

Technology Trends

Technology trends spearheading development of an information society



TT01

Intellectual Advancement of AI



TT02

Coexistence with AI



TT03

Data-Driven Transformation



TT04

AI for Healthcare & Life Sciences



TT05

Security for the Digital Era



TT06

Computer Power Evolution



TT07

Synergy in Human-Machine Systems



TT08

Hardware Evolution for Service Operations



Technology Trend 01

Intellectual Advancement of AI

Advanced language proficiency for AI such as translation and summarization is reaching human ability. Modeling human cogitation, AI will gain new capabilities through varied and diverse research efforts. Such ability includes flexibility by applying knowledge and experience once learned and logical thinking by inference using causality.

Having gained notoriety based on its successful image recognition, third-generation AI continues to strengthen its capability in the field of language processing. This is enabling AI to genuinely assist in the intellectual activity and capacity of humans.

The end of 2018 saw the emergence of an AI that takes in huge amounts of discourse directly from the internet, learns language rules and performs various processes that involve language, sometimes at a level that exceeds human capabilities. Stimulated by this progress, more learning data, robust computing power and efficient algorithms are being generated daily. Thus the global AI development competition continues.

While AI's ability is getting closer to humans, many issues remain. AI models lack versatility, and a different

one is needed for each application. The one-off nature of this makes it inefficient. Additionally, AI performance depends on the amount and quality of learning data. This means that AI is of little value in fields with very little historical data.

For this reason, efforts are continuing to create AI that overcomes these restrictions. Just like human children learning about the world, this future AI will accumulate and apply the knowledge it has learned in one area to others, hypothesizing and validating to establish new rules. The continued development of such technologies will likely improve the versatility and capacity of AI learning, making it far closer to that of the human brain in order to apply knowledge in diverse ways.



Technology Trend 02

Coexistence with AI

AI presently coexists within society. In daily life, numerous individuals use AI and rely and benefit from its capability. Addressing issues such as an explanation of specific results, establishment of quality standards, prevention of discrimination and countermeasures for vulnerability, are essential for continued acceptance and progress.

Technologies are being developed to broaden the scope of AI making it easier to use. At the same time, the issues created by increased accessibility to AI must be recognized and solved.

Tools that make using AI easier are improving significantly. An internet connection is all that is needed to access free tools to learn and use AI today. Special devices, software and practical knowledge are all accessible online. Future-focused, technological development is currently underway that will assist AI in acquiring knowledge and making judgments the way people do in their daily work and lives.

However, in an emerging society with human-AI coexistence, issues are certain to proliferate stemming from AI attributes. Efforts will also increase to address

problematic cases of its use that create unexpected discrimination, fail to explain outputs and unrecognized certain kinds of computer attacks.

Furthermore, in contrast to rapid technological advancement and popularization, neither the criteria for judging the good and bad of AI itself, nor the critical issues to consider when using it, are yet to be completely determined. This will likely become a pressing task as we translate the fledgling principles of AI use into concrete action guidelines.



Technology Trend 03

Data-Driven Transformation

Data is now the bedrock for growth. Capturing data from unprecedented sources combined with mechanisms for aggregation and analytics will enable new levels of convergence between the digital and physical worlds. This in turn will bolster data-driven decision making and accelerate transformation.

Centered around customer contacts, efforts to use a data-driven process to improve services in a rational and thorough way are about to expand to achieve competitive edge. In addition to services, it is inevitable we will see an ongoing process where more fields get digitized, including production and logistics, toward a more holistic integration.

It is the smartphone that drives data-driven processes in the service industry, powerfully promoting the digitalization of the customer experience. The aggregate of sensors that collect detailed data and cellular, wireless technology, which is equipped with a high-speed communication capability and also acts as a contact point for customers, has made it possible to thoroughly individualize, optimize and continuously improve services.

Providers that make maximum use of these capabilities gain an overwhelming competitive edge destroying existing business processes.

There are additional technological advancements underway to expand these capabilities to include both logistics and production sites. Examples of these include sensing via intelligent edge and satellites, communication technologies including 5G and lower prices of cloud-based data accumulation analyses.

The expansion of data-driven processes are anticipated to change the way companies operate and transform business models. One can easily envision a future where companies excelling in technologies that increase data value via sensing and analysis can establish new brands that go far beyond their existing business.



Technology Trend 04

AI for Healthcare & Life Sciences

AI-assisted medical diagnosis along with the use of more precise and comprehensive data is becoming more accepted and prevalent in practice. Augmenting healthcare workers with AI innovations such as pattern search for genome data and structure prediction for protein promise further advancements in healthcare and the life sciences.

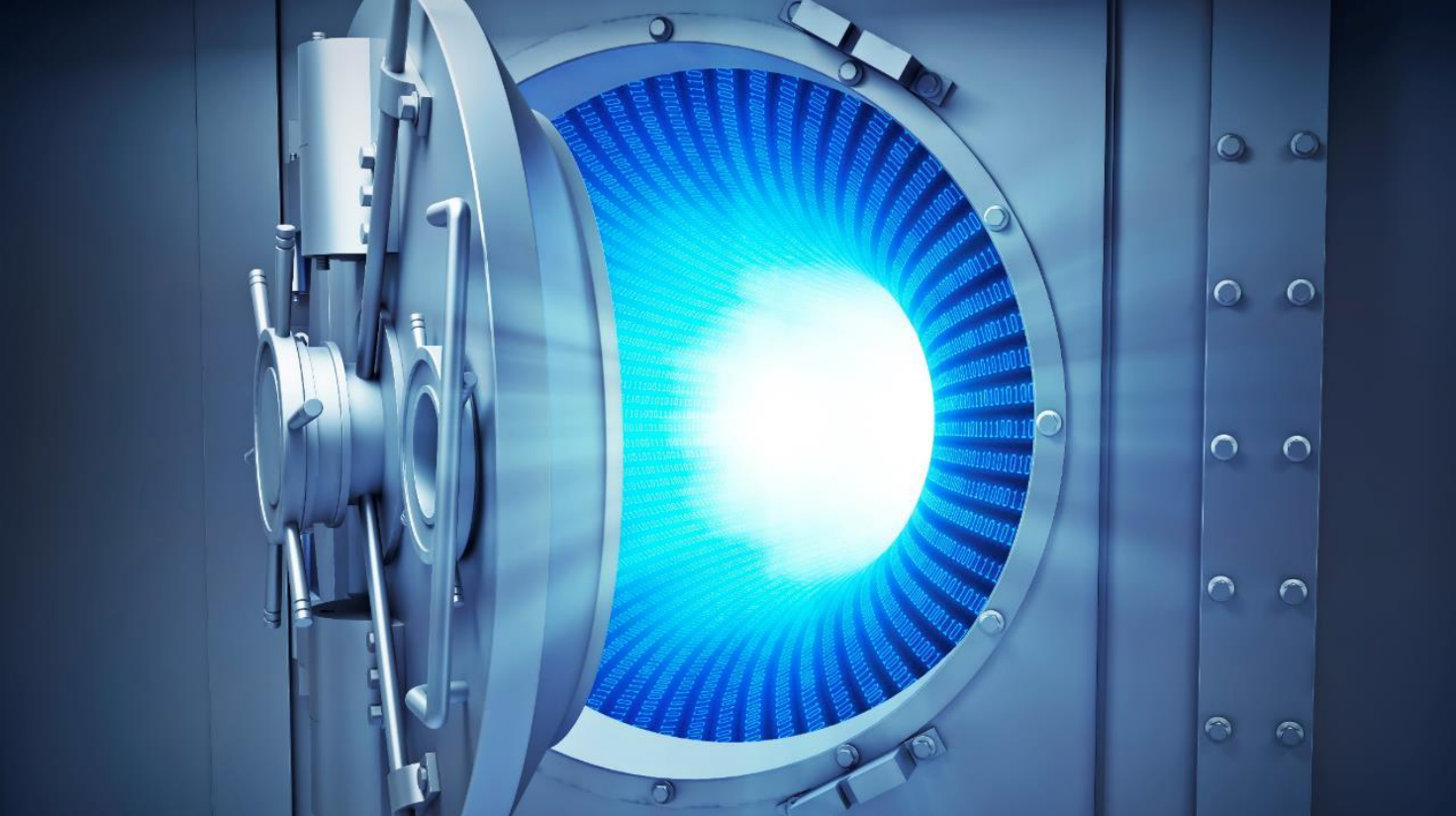
Data utilization is active in many areas of healthcare, significantly impacting the pursuit of health.

AI-based image diagnosis and treatment, which is fueled by huge amounts of data stored at medical institutions, is starting to provide robust assistance to physicians with accuracy comparable to physicians. Some of the AI are providing functions that mimic actual medical practices, including detection of multiple illnesses. Additionally, AI is showing promise inferring mutated genes based on images that may revolutionize the traditional diagnostic processes.

Data that can be acquired from our daily lives also contributes significantly to our health. For instance, continuous acquisition and analysis of biological information such as heart rate has enabled abnormalities to be detected sooner in an asymptomatic stage. In addition, the use of DNA information to huge numbers of

people is helping identify genetic risks involved in many illnesses. The emergence of health-related analysis services that combine such functions and technologies is moving us toward a day when disease prevention is individually optimized.

Fundamental elucidation of diseases for which only symptomatic therapy is available will move human healthcare into a completely new phase. In recent years, efforts to better understand the mechanism of the human body has shifted into high gear to establish breakthrough therapies for intractable diseases. These efforts include the inference of the 3D structures of proteins, and the acquisition and analysis of more elaborate brain data. Data-driven healthcare is further expanding its boundaries, bringing new possibilities toward the resolution of life-related issues.



Technology Trend 05

Security for the Digital Era

Given the limitless application of data, its protection is being re-engineered. On top of traditional protection methods, organizations are implementing zero-trust security measures to counteract breaches quicker and to minimize damages. Business leaders are also adopting privacy protection technologies to keep individual data anonymous.

In an age where data utilization has become a prerequisite for business, the data of individuals keeps increasing in value. For this reason, service providers will only gain the trust of individuals by maintaining a safe environment for their data.

The foremost prerequisite for such trust is to protect data from malicious attacks. As the use of mobile and cloud services spread, the traditional concept of protecting against all intrusions has reached its limit. Under these circumstances, today's emerging technologies aim to minimize the damage of an intrusion, including the use of automatic log analysis to achieve immediate detection of abnormalities and the encryption of low-spec edge devices for even more robust protection.

Individual-centered data use, too, is becoming

increasingly important. As global legislation is developed regarding data utilization, technologies are also evolving that enable service designs to let individuals control their own information and to allow the anonymous use of data. Pursuit of these solutions will contribute significantly to winning the trust of individuals.

Balancing between the public interest such as people's lives and safety and the protection of privacy is controversial due to IT's inherent ability to track personal information. As a result, we are reaching a point where a new norm is needed. To win the leadership of future society and business and maintain the trust of individuals, it will be essential to maintain the proper balance between these conflicting forces.



Technology Trend 06

Computer Power Evolution

The inexhaustible demand for computing power is being tackled through a combination of new, denser chips and application-specific architectures. To solve power requirements additional new materials like carbon nanotubes, and approaches like photonics and neuromorphic architectures are also being investigated and introduced.

The need for computing power combined with the insatiable use of AI capabilities will not only help technology to continue improving, but also generate additional technologies for completely new IT infrastructures.

AI's accuracy increases as it learns more data and it computes more volumes. This attribute of AI continues to strain the computer power of existing IT infrastructures. Responding to this necessity are advancements in miniaturization technology for semiconductors and the development of processors specialized for individual processing purposes such as learning and extrapolation by AI. However, there are large obstacles that must be overcome such as the level of technological difficulty as

well as increased costs and huge power consumption requirements.

Meanwhile, research and development of some completely new IT infrastructure technologies are beginning to show positive results including a power-saving, high-efficiency processor that imitates the human brain, new semiconductor material and the comprehensive use of optical communication.

What is interesting is the fact that service providers are engaging in such high-risk investments like the development of specialized processors and new IT infrastructures to improve their competitive edge. In the future, important decisions must be made regarding the strategic use of alternative IT infrastructures in business.



Technology Trend 07

Synergy in Human-Machine Systems

Pervasive AI is redefining the relationship between humans and machines. Human-machine synergy in systems driven by AI will create added value. For example, AI may offer safer driving for unanticipated dangers in automobiles, but humans can provide flexibility to adapt to changing conditions.

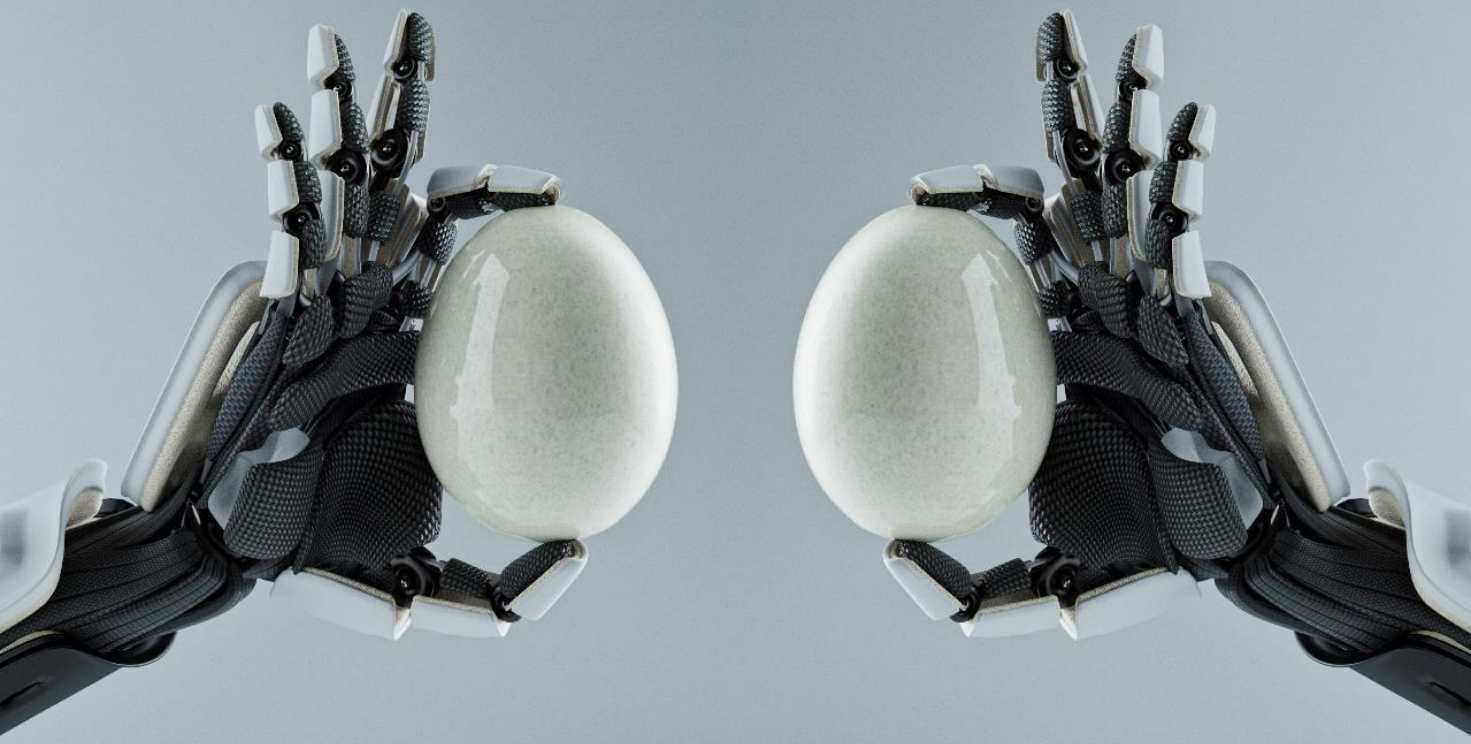
To use machines efficiently, humans have adjusted their activity to a machine's interface. AI brings about a new way of using machines where humans and machines cooperate on a task. This new way is expected to initiate a dramatic innovation in services that will make maximum use of IT's advantages.

For example, surgery-assisting robots with stereoscopic vision and a sense of touch enable physicians to experience procedures as if they are operating directly with their own hands. Direct presentation of intuitive information to others has enabled surgery that is far simpler and less burdensome to the patient than traditional endoscopic surgery.

In addition, AI-based behavior recognition technology has made it possible for machines to actively support humans. Grab-and-go stores, as an example, continually

monitor customer behavior on premises so that all customers need to do is to pick up the desired merchandise and leave without thinking of paying. This is a new type of brick-and-mortar shopping experience where customers are not required to interact with either AI or machines.

A cooperative relationship between humans and machines can be established using an intuitive machine that maximizes human ability, the AI-enabled active support by machines and/or the combination of these two functions. The advantages of IT can be utilized more than ever before by combining the flexible behavior of humans with the more accurate and speedy decision-making of machines. The pursuit of such human-to-machine interactions will advance the relationship between human and machine to a new level while inspiring service innovation.



Technology Trend 08

Hardware Evolution for Service Operations

To operationalize service chains with IT, hardware must permeate operations in areas never thought possible. Hardware combined with AI acquires the capability to understand complex surroundings and undertake dexterous operations. As a result, evolved hardware with extensive use of IT is expected to revolutionize service operations.

Businesses powered by IT continue to grow in a flexible and rapid fashion due to the nature of software. However, this growth is limited as long as physical tasks that support its growth depend on manual labor. To overcome this limitation, robots combined with AI are taking a role.

One example of this is the advent of the delivery robot, which physically delivers products ordered online to a customer location. Given accurate eyesight by the AI, the robot can now observe road signs and traffic signals while safely avoiding pedestrians and surrounding obstacles. Additionally, the AI learns huge amounts of behavioral data collected by simulation and uploads it to the robot. This has made it possible for the robot to move its arms like a human, which has previously been difficult to achieve. This acquisition of dexterity can support

more elaborate assembly tasks using tools, greatly expanding the scope of applications for robots.

The use of less expensive parts has also contributed to the emergence of a robot with softer joints, although with a somewhat lower accuracy of movement. A robot made with soft material is safer for the surroundings. By changing its shape according to the environment, we can also expect robots to work at locations where it has traditionally been difficult to use, such as a disaster site. Robots that combine soft material, AI-assisted eyesight and that mimic human movement would be able to perform very, complex tasks. The day may soon come when such a robot is available at low cost. These robots will act as a new interface between IT services and the physical world, supporting the expansion of service areas.



NTT DATA Corporation

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

Tel: +81 50 5546 2308 www.nttdata.com

NTT DATA Technology Foresight

Strategy Development Section

Research and Development Headquarters

rdhkouhou@kits.nttdata.co.jp

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

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