Enrich Society

P. 018

Contribute to Society through ICT and Data Usage

66
Number of B2B2X projects

10
Number of UD-capable products and services provided

P. 022

Pursue Customer Satisfaction

79.4 %
Response rates at our call centers

369
Number of improvements made based on suggestions from customers

P. 024

Reinforce and Globalize Research and Development

0.87
Number of patent applications per employee

0.82
Number of academic papers published outside the company per employee

Enrich Society

CSR Priority Activities	Medium-term Targets	CSR Quantitative Indicators	KPI	Target Achievement FY	Result (FY)		
					2017	2018	2019
Contribute to society through ICT and data usage	Evolve into a B2B2X business model which uses digital services and data management	Number of B2B2X projects	100 projects	FY2021	—	39	66
	Leverage the characteristics of 5G to create new value with a broad range of partners	5G service-related indicators*	To be set at the commercialization stage				
	Promote personalization to support changing lifestyles	Number of places where payments can be made and points can be used*	Two million places	FY2021	0.84 million	1.05 million	1.71 million
	Provide ICT services available for a broad range of customers, including the elderly and persons with disabilities	Number of UD-capable products and services provided	Expand	—	14	12	10
Pursue customer satisfaction	Provide high value-added products and services and fine-tuned support	Reductions in waiting and customer service times at DOCOMO shops*1	Decrease by half compared to FY2018 (over 2 hours on average)	—	—	—	65 minutes
		Number of improvements made based on suggestions from customers	More than in the previous fiscal year	—	496	399	369
		Response rates at our call centers	Better than in the previous fiscal year	—	88.6%	86.5%	79.4%
Reinforce and globalize research and development	Globalize and expand the competitiveness of research and development to generate world bests, world firsts, and amazing results	Number of patent applications*2	More than in the previous fiscal year	—	0.82 applications /employees	0.85 applications /employees	0.87 applications /employees
		Number of academic papers published outside the company	More than in the previous fiscal year	—	0.76 publications /employees	0.76 publications /employees	0.82 publications /employees
		Number of successful practical applications*	More than in the previous fiscal year	—	0.064 publications /employees	0.070 publications /employees	0.066 publications /employees

*1 Newly established in fiscal 2019

*2 Past figures have been retroactively revised to reflect a change in the calculation method.

Contribute to Society through ICT and Data Usage

Relevant GRI Standards: 103-2/203-1,2

Policies and Concepts

In recent years, various social issues have come to the fore: rapid increase in the global population, growing severity of natural disasters, worsening of food supply and environmental problems, and in Japan, low birthrates and an aging population are leading to a rapid shrinking of the working-age population and shortage of labor. To solve these problems, significant social and economic transformations are being demanded in every society and economy, and the advancement of digital transformation utilizing ICT (Information and Communications Technology) is required in every situation. Collaborating with companies in different industries and local governments as Your Value Partner, the NTT Group has been applying its management resources and capabilities, including human resources, research and development, and the ICT base to promote digital transformation and resolve social issues. Going forward, we will seek to make a greater contribution to society based on our awareness that utilizing the power of ICT and data will be particularly effective for promoting the B2B2X business model, rolling out the 5th generation wireless system, creating new lines of business, and contributing to the vitalization of regional societies and economies, which constitute the pillars of our medium-term management strategy.

Organization for Implementation

The NTT Group has made promotion of the B2B2X business model one of the pillars of our medium-term management strategy and has been taking action by establishing a B2B2X Strategy Committee with the president as chairman to facilitate Group collaboration while expanding projects. We are also deepening discussion about future deployment of the B2B2X business model at regularly held Board of Directors meetings and reporting on progress at general meetings of shareholders.

Main Initiatives

Promoting the B2B2X Business Model

The promotion of the B2B2X business model is an initiative for transitioning from our previous model, in which the NTT Group provided individuals and companies with direct services, to a new model which delivers added value to end users through support for service providers across a range of fields.

Facilitating collaboration with partners

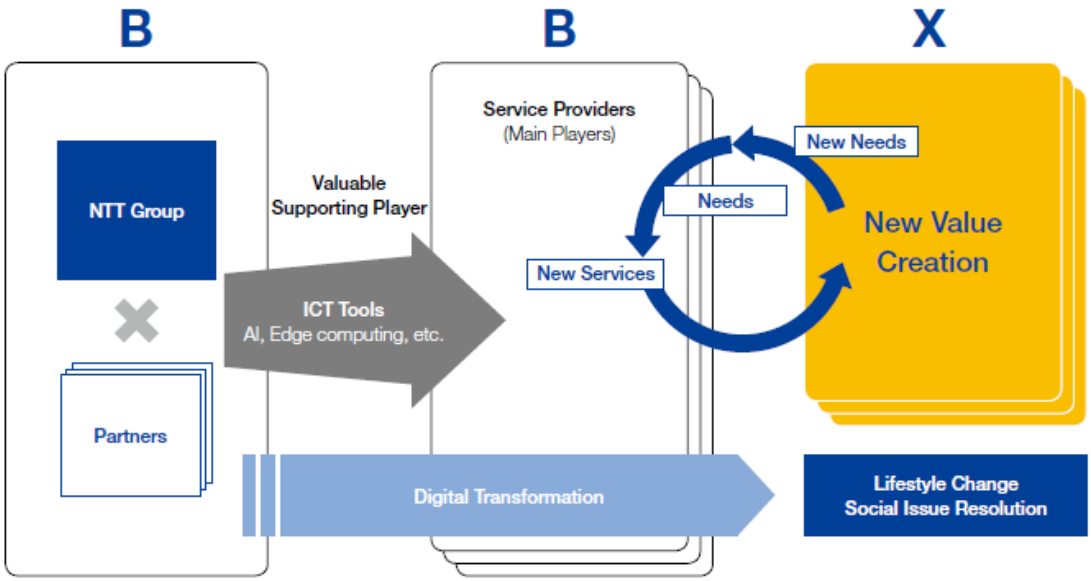
- Entered into a business alliance with Mitsubishi Corporation in December 2019 to transform industrial value chains and to generate new value through digital transformation and completed the joint acquisition of HERE Technologies, a global service provider in location-based services based in the Netherlands.
- Agreed to form a multi-year strategic alliance with Microsoft Corporation in December 2019 to promote the creation of a Global Digital Fabric, development of digital enterprise solutions, and co-innovation of next-generation technologies to deliver secure, reliable solutions that help enterprise customers accelerate their digital transformation.
- Entered into a business and capital alliance with Toyota Motor Corporation in March 2020 to establish a long-term, ongoing cooperative relationship that enables the commercialization of businesses to realize smart cities that continue to evolve in accordance with resident needs.

Developing a Smart Agri-City

- Expanded the scope of the Community Development Partnership Agreement, signed with Sapporo City in 2015, to 12 municipalities in the Sapporo Metropolitan Area.
- Entered into an industry-government cooperation agreement with Hokkaido University and Iwamizawa City in June 2019 with the goal of creating a smart agri-city.
- Entered into a comprehensive cooperation agreement with Chiba City in July 2019 for future community development.

Going forward, as we advance personalization and the realization and deployment of 5G through the expansion of the B2B2X business model, we will support our customers in their digital transformation and contribute to the realization of a smarter society.

B2B2X Business Model



Initiatives for the Realization and Deployment of 5G

We launched our commercial 5G services in March 2020, and we will provide billing plans such as 5G Gigaho and 5G Gigalight, seven types of 5G devices, services in the gaming, music and sports genres, and solutions that contribute to advancing industry and driving digital transformation. Furthermore, we are promoting initiatives that will increase convenience and enrich people's lives by creating new value and offering solutions for social issues toward our goal of introducing 5G services in more than 500 cities by the end of fiscal 2021.

Creating New Lines of Business

Initiatives in the Location Business

There is growing expectation that the connection of all things and people via the Internet will advance intellectual productivity and enhance the quality of offices and daily lives, leading to a broader use of location technologies that make this possible.

- Investment in HERE Technologies

  NTT will strengthen location information services as a core function of the Industrial DX Platform that is being established in collaboration with Mitsubishi Corporation. As a concrete example, we will seek to develop a service that identifies optimal distribution routes by utilizing the world's largest and most accurate location information database owned by HERE Technologies to visualize vehicle locations and operational status. We are studying alliances with logistics partners involved in home delivery (last-mile delivery) and trunk line transportation (mid-mile delivery), where demand is expected to increase, toward launching several Proof of Concept projects by the end of fiscal 2020.

- Capital and business tie-up with ZENRIN

  NTT entered into a capital and business tie-up with ZENRIN Co., Ltd. to expand its respective businesses in the fields of infrastructure management, MaaS and autonomous vehicles as well as smart cities and contribute to the 4D digital platform™ envisioned by NTT. Beginning in fiscal 2020, we will jointly construct a high-precision Advanced Geospatial Information Database with an abundance of location information. In doing so, we will draw on the know-how of the NTT Group in high-accuracy positioning and mapping technology as well as infrastructural maintenance and management and ZENRIN expertise in the production of maps incorporating a broad range of collected information.

Providing Services that Support Healthcare Management

In April 2020, NTT Life Science launched the "Genovision" corporate wellness support service to help companies promote healthcare management and boost employee health. In Japan, low birthrates and the aging population have led to rising medical costs, with expenses for treating lifestyle diseases accounting for a major proportion. Meanwhile, companies are being required to consider maintaining and improving employee health from a management standpoint and conduct healthcare management as part of their corporate management strategy. To address these needs, Genovision will help improve lifestyles optimized for each individual employee by harnessing the NTT Group's accumulated technologies in ICT and security to conduct big data analysis based on healthcare data and genomic information.

Contributing to the Vitalization of Regional Societies and Economies

We endeavor to resolve social issues faced by local governments and regional companies as our contribution to the vitalization and development of regional societies and economies. We are engaged in creating completely new value across broad areas, including agriculture and medical services, by utilizing the NTT Group's total capabilities and ICT in collaboration with our partners.

- NTT AgriTechnology Corporation was established in July 2019 as the first company specializing in combining agriculture and ICT in the NTT Group toward revitalizing agriculture-based communities by utilizing IoT/AI technology.
- NTTe-Sports was established in January 2020 in a joint venture with SKY Perfect JSAT Corporation and Taito Corporation toward contributing to local communities by combining ICT and eSports.

Advancing Personalization by Supporting the Transformation of Lifestyles

We support customers as they transform ever-diversifying lifestyles by providing personal solutions centered on DOCOMO that closely align with individual needs. Subscribers to Gigaho and Gigalight, which are simplified and reasonable billing plans introduced in June 2019, totaled 17.87 million as of the end of June 2020.* In terms of service, we are enhancing electronic payment and contents while utilizing AI and big data to improve communication with every customer.

* The number of subscribers is the combined total for the Gigaho, Gigalight, 5G Gigaho, 5G Gigalight, Keitai Plan, Kids Keitai Plan, Data Plus and 5G Data Plus billing plans.

Promoting Digital Transformation

We are raising operational efficiency by introducing robotic process automation (RPA)*1. The operational process has been adopted in approximately 2,900 cases within the NTT Group as of the end of June 2020. We are also recommending the use of RPA among our customers, and more than 5,200 of them have adopted the process as of the end of June 2020. We also sought to advance our Group management by actively introducing a unified enterprise resource planning (ERP)* system for our personnel, finance, and procurement operations.

*1 Solution for automating operations previously handled by humans by establishing procedural rules to replace humans with robots.

*2 Management method for implementing centralized management of corporate resources to achieve optimization across the entire company.

Initiatives for Universal Design*

The NTT Group actively encourages the broader adoption of universal design, which ensures that products and services are easy for all customers to use, regardless of age, gender or physical abilities.

* Products and services that can be used by senior citizens, children, persons with disabilities, and foreign visitors facing language barriers (includes expanded functions)

Examples of Universal Design Products and Services in Fiscal 2019

- Oshaberi Annaiban, an AI-based information board capable of engaging in natural conversation
- Smart Room Mimamori, a system for monitoring elderly citizens
- Home Currency Anywhere, which allows consumers to use their own country's currencies anytime, anywhere
- Face Sharing, a technology that reproduces the mouth movements and facial expressions of someone else onto the user's own face
- Small self-driving mobility technology and free rental service for next-generation electric wheelchairs

Establishment of the NTT Group Web Accessibility Policy

The NTT Group is working to ensure and improve the accessibility of its websites for a wide spectrum of customers, including senior citizens and persons with disabilities.

Specifically, the Group established the NTT Group Web Accessibility Policy. The policy for official websites of the Group companies with head office functions in Japan is set according to JIS X 8341-3:2016*1 and each works to comply*2 with Level AA.

*1 JIS X 8341-3:2016: "Guidelines for older persons and persons with disabilities—information and telecommunications equipment, software and services—Part 3: Web content" of Japanese Industrial Standards

*2 Refers to compliance with the description defined in the "Compliance Performance Announcement Guidelines for JIS X 8341-3:2016. March 2016 Edition (published on March 22, 2016)" of the Web Accessibility Infrastructure Committee, Info-communication Access Council. This means that we have established and disclosed an accessibility policy and confirmed that the pages fulfilled all the requirements through the tests implemented and based on JIS X 8341-3:2016.

About the Web accessibility efforts of the NTT Group https://www.ntt.co.jp/apolicy/ (Japanese only)

User-Friendly Service Lineup

We offer a broad range of discount services for various users, including senior citizens and persons with special needs, to facilitate access to ICT services.

Special discounts on dedicated lines for educational facilities (NTT East and NTT West)

Since January 2001, NTT East and NTT West have offered special fees for schools on FLET'S services suitable for using the Internet at a fixed sum in an effort to promote educational use of the Internet.

- NTT East https://business.ntt-east.co.jp/service/schoolplan/ (Japanese only)
- NTT West https://flets-w.com/limited/school/ (Japanese only)

Discounts on mobile phone use for persons with special needs (NTT DOCOMO)

NTT DOCOMO offers the Hearty Discount programs for encouraging more social participation by persons with disabilities.

Examples of Hearty Discount Programs

- 370-yen discount on DOCOMO's GIGA plans (includes discount for sp-mode usage)
- 1,700-yen discount on basic plans such as the Kake-hodai (unlimited calling) plan
- 60% discounts on FOMA payment plans and monthly fees on various services
- Partial elimination of charges for some subscription options
- Setting of video phone call charges at the same level as voice call charges
- No charge for dialing and obtaining information via 104 directory assistance

https://www.nttdocomo.co.jp/charge/discount/hearty/about/index.html (Japanese only)

Pursue Customer Satisfaction

Relevant GRI Standards: 103-2/203-1

Policies and Concepts

The NTT Group serves various customers, from general consumers to corporate customers, providing a broad range of products and services.

Its main business fields, the telecommunications and ICT industries, continue to innovate, producing new products and services. Mobile devices such as smartphones and tablets continue to evolve almost daily, giving rise to a number of new services utilizing the NTT Group's network. At the same time, with the evolution of technology and services, the amount of information needed to use them has increased, and this has also increased opportunities for us to receive various confirmations, inquiries, feedback and requests from customers with regard to device malfunctions and questions about various fees and services.

The NTT Group believes that helping eliminate customers' concerns or doubts about the services they use and maintaining a high level of satisfaction among all customers will give rise to relationships of trust with customers and lead to the acquisition of new customers.

Organization for Implementation

The NTT Group companies have built a system for making operational improvements that will lead to reductions in the time taken to respond to customers, enhancing products and services, and influencing development based on the voice of customers received through surveys, the Customer Services Center, and other departments. In turn, we work toward developing and providing services closely in tune with the voice of our customers. Specifically, we work continuously to improve our year-over-year results for the KPIs of the reduction in waiting and customer service times at DOCOMO shops, the number of improvements made based on suggestions from customers, and the response rate of our call centers, which will give rise to a positive cycle of improvement.

The NTT Group will keep on making efforts to raise the level of customer satisfaction, including service quality and on-site responsiveness required by customers, in conjunction with the business operations of individual NTT Group companies.

Main Initiatives

Customer Contact Points

Each Group company has set up a call center that responds to customer inquiries on products and services, requests for repairs, and complaints.

Major call centers of the NTT Group receive over 180,000 calls each day and endeavor to respond promptly to customers. Each call center has set its own targets aimed at improving response rates and enhancing the quality of responses and support. They also engage in various efforts including telephone response competitions and training to enhance skills for providing better responses.

Reflecting the Voice of Customers

The NTT Group listens to the voice of its customers, including their opinions and requests, through its call centers. Each Group company has constructed a system for reflecting the voice of customers in making operational upgrades and improving and developing products and services, and they are making an active effort in related activities as well.

For example, NTT Communications collects the voice of customers through various contact points in an effort to reinforce initiatives for enhancing services and improving operational processes. This includes not only annual surveys, but also soliciting customer feedback at the time of application and during various support processes.

For more information on these initiatives, please refer to each company's website, CSR Report, and other materials.

- **NTT East "Service with a Smile" activities** http://www.ntt-east.co.jp/smile/ (Japanese only)
- **NTT West "Customers First" activities** https://www.ntt-west.co.jp/withc/ (Japanese only)
- **NTT Communications "For Increased Customer Satisfaction"** https://www.ntt.com/about-us/cs/cs.html (Japanese only)
- **NTT DOCOMO "Initiatives That Utilize Feedback from Customers"** https://www.nttdocomo.co.jp/support/cs/case/index.html (Japanese only)

COVID-19 Outbreak and Support for Customers

In March 2020, NTT Group companies announced their policy of extending payment dates upon request from customers facing difficulties in paying for services on time.

Recognizing that the government's stay home request created an environment that made it difficult for customers to use their d POINTS, NTT DOCOMO decided to reactivate d POINTS that expired between March and May 2020 and award them to customers, effectively extending their expiration dates.

In light of schools implementing remote classes and online education, in April 2020 NTT DOCOMO and NTT Communications announced a partial waiver of data communication fees for customers 25 years old or younger to support the use of smartphones for online learning.

Furthermore, NTT Group companies have been supporting telework, education, and health by setting up customer contact points and providing some services free of charge as initiatives. At the same time, the NTT Group has been using cell phone data to analyze demographic changes caused by government policies addressing the spread of COVID-19 and providing information to central and local governments and the media.

Reinforce and Globalize Research and Development

Relevant GRI Standards: 103-2/203-1,2

Policies and Concepts

As ICT companies leading the world, the NTT Group recognizes R&D as a material issue that gives Group companies their competitive edge. R&D supports the digital transformation of our customers and lifestyle transformations tailored to individuals, and the R&D department works with operating companies to develop new technologies that provide the wellspring for new value creation in a variety of domains to enhance the NTT Group's R&D, a pillar of our medium-term management strategy. The NTT Group seeks to overcome numerous problems involving safety, disaster readiness, and the improvement of productivity through R&D and, as a result, strengthen industrial competitiveness and resolve social issues. Since ICT is applied in a variety of fields, we are forging partnerships with counterparts in wide-ranging industries as we pursue our R&D initiatives.

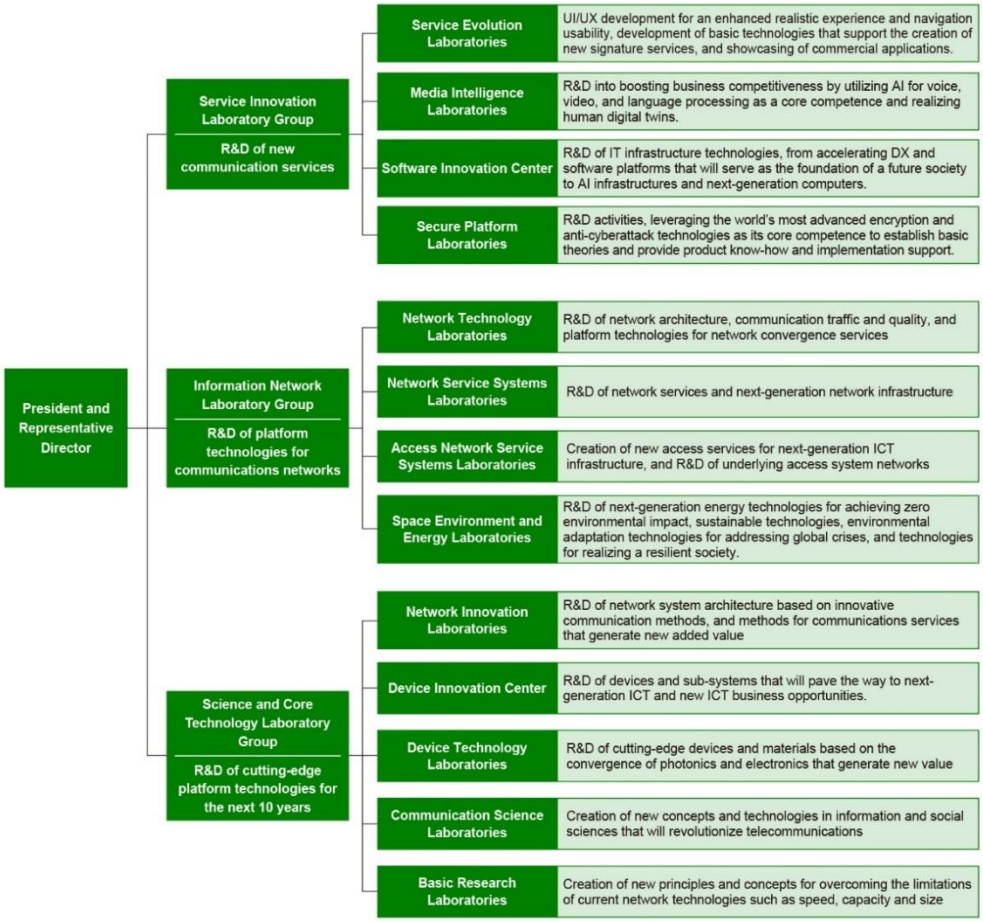
Organization for Implementation

With respect to R&D undertaken by the NTT Group, NTT's three laboratory groups are responsible for conducting basic research that serves as the backbone of telecommunications, such as basic and component technologies related to services and networks, while each operating company conducts applied research that is more closely related to its business.

NTT Group's Overall R&D Organization (as of March 31, 2020)	
Number of Researchers	Approx. 5,000
R&D Expenses	220 billion yen/year

Also, we promote general producer activities, in which we formulate marketing and business plans and forge alliances so that the results of research by NTT laboratories can be transformed into Group businesses. In these general producer activities, we seek to develop business in a timely manner by combining the wide-ranging basic technologies of NTT laboratories with external technologies in collaboration with Group companies and with various other companies to create new services.

In order for innovation to continually be an important driver of the NTT Group well into the future, we will aim to contribute to the realization of a sustainable society by promoting innovations for social issues. These efforts will include patent applications and the publication of scientific papers.



Enhance and Globalize R&D

The NTT Group is advancing innovative research and development that drives change worldwide while stepping up basic research at overseas centers. Specifically, we will use the research centers established overseas to strengthen joint research with a varied range of research bodies, actively utilize the latest external technologies, and increase investment in research on new growth fields. We will also promote the global rollout of R&S results and globalization of research targets.

In July 2019, we opened NTT Research, Inc., which operates three research laboratories, in Silicon Valley in the United States for the purpose of reinforcing fundamental research. We have launched a collaboration with universities and research institutes in the United States and Europe in the fields of quantum computational science, medical/health/healthcare, and basic cryptography/blockchain. We will further globalize our research and development by opening research centers in areas around the world, starting with Silicon Valley.

Main Initiatives

Research and Development to Promote the B2B2X Model

Promoting the B2B2X business model is a central pillar of the NTT Group's initiatives contributing to the realization of a smart society. In the B2B2X model, instead of providing services to customers directly, the NTT Group supports service providers by offering ICT tools such as AI and IoT, to which various values are added before being delivered to customers.

In addition, the NTT Group has been working to realize B2B2X models with many partner companies and local governments. We will further evolve them and advance a model that uses digital services and data management.

- We have been working together with Mitsubishi Heavy Industries, Ltd. to promote the transformation of manufacturing technology in the social infrastructure industry. By applying communication-grade optical fiber technology with laser processing, we have succeeded in transmitting high-power single-mode laser light, whereas, conventionally, such transmissions have been possible only up to several meters. This research success opens the door to higher efficiency and precision in laser processing while expanding applications into new fields. The technology is expected to spark innovation in manufacturing.
- In the ongoing migration from Public Switched Telephone Networks (PSTN), we have developed fundamental technologies that enable the use of metal cables of conventional telephone networks to connect with the IP networks operated by NTT East and NTT West (next-generation networks, NGNs) through transfer switches, which connect with other carriers through IP and migrate tandem/signal switches to IP. We will continue to pursue the initiative toward its scheduled completion.

Research and Development Aimed at Achieving Immersive and Natural Worlds

NTT has further evolved its Kirari!® processing technology, which aims to create worlds that provide "just like being there," ultra-high immersion experiences in real time that can be accessed anywhere. The newly developed techniques not only enable the acquisition and transmission of the images of subjects from video broadcasts, along with 3D positioning information, but also allow them to be reproduced at the destination in a pseudo-3D display that generates the sensation that the subjects also move toward and away from the viewer. This results in the achievement of an audience experience in which the subjects appear to move in three dimensions at the destination.

For example, in a sports match, the technology can project a pseudo-3D display of an athlete onto a stage and give a real sense of the projected athlete moving nearer or further away through synchronization with the movements of the athlete in the actual event being broadcast.

- Signed a multi-year partnership with Major League Baseball (MLB) in the United States as a smart sports initiative aimed at promoting NTT's latest technologies to deliver next-generation baseball viewing experience. A Proof of Concept using NTT's Ultra Reality Viewing technology (URV) was conducted in October 2019 during the post-season games of the MLB, providing the world's first successful demonstration of an immersive live-viewing experience by combining and transmitting 12K super-wide-screen video images.

Promoting Cutting-Edge Research

With large capacity optical networks expected to evolve further to facilitate the widespread use of IoT and 5G services, we are newly developing our own digital signal processing and ultra-broadband optical device technologies, and we have become the first in the world to successfully test the long-distance transmission of a wavelength division multiplexed optical signal. We also successfully used two technologies for large-volume wireless transmission, as described below. In addition to these, we are advancing cutting edge research, such as the joint development with a university of an ultra-high-speed integrated circuit that enables wireless transmission.

Increasing the Capacity of Optical Fiber Communication Networks

Increasing the capacity of mission-critical optical fiber communication networks has become an economic necessity. We have developed new proprietary technology for digital signal processing and ultra-wide area optical devices, increasing the

channel capacity per wavelength to the point that transmission speeds achieve a level more than 10 times that of current commercial systems, and achieving a global first of 1 terabit/sec of capacity in long-distance wavelength-division multiplexed transmission trials. Furthermore, we also succeeded in developing an ultra-high-speed compact optical front-end module with integrated compact, wide-band InP optical modulator.

As another accomplishment, we realized high-capacity wireless transmissions at approximately 10 times the speed of LTE and Wi-Fi, and five times that of 5G, by using the following two technologies.

The first one enables wireless transmissions at rates of 100 Gb/sec by using a method devised by NTT combining a principle called “OAM multiplexing” with MIMO technology. This generates multiple radio waves of different frequencies so that they can transmit simultaneously without interfering with the each other. The result is a dramatic increase in the volume of data that can be transmitted simultaneously, enabling large-capacity communications.

The second one, which was jointly developed with the National University Corporation Tokyo Institute of Technology, enables wireless transmissions of 100 Gb/sec in the 300 GHz band. It is easier to expand the transmission bandwidth or terahertz waves, including the 300 GHz band, although they require high-performance devices. We developed an ultra-high-speed integrated chip (IC) for wireless frontend devices, leading to the world’s first 100 Gb/sec wireless transmission in the 300 GHz band.

Optical Transistor Capable of High-Speed Operation with Ultra-low Power Consumption

As Moore’s law approaches its limit in electronic circuits, there are expectations for a new, high-speed, energy-saving computing platform that incorporates optical technology. Achieving this requires technologies that have hitherto been considered difficult to achieve with low energy consumption, such as opto-electronic signal conversion and high-speed signal processing in the optical area. NTT has been developing a semiconductor nanostructure called photonic crystals with which to realize various tiny optical devices. In this work, we used our nanotechnology to realize a nano electro-optic modulator (E-O converter) and a nano photodetector (O-E converter) with extremely small capacitance and low energy consumption. Moreover, through their integration, we also realized an O-E-O conversion optical transistor. These nano-optical technologies have opened the way to realizing high-speed, low-energy integrated opto-electronic information processing.

Looking to the Future: IOWN

NTT R&D is envisaging the arrival of new smart societies that are not yet possible with today’s Internet, with features such as mobility as a service (MaaS) for extreme fail-safe systems and entertainment services offering deep immersion. To realize such smart societies, we will require innovation that cannot be achieved merely by extending the trajectory of current technologies; we will need to realize ultra-low power consumption, high-speed signal processing, and the fusion of virtual worlds that can equal or surpass reality with sophisticated prediction technologies. The NTT Group has proposed the Innovative Optical and Wireless Network (IOWN) concept to realize new smart societies, and we are committed to realizing this concept.

In January 2020, the IOWN Global Forum was established in the United States by industry leaders NTT, Intel Corporation, and Sony Corporation, all three of which have superior expertise in the technological areas that form the core of IOWN. Wide-ranging recruitment efforts began in March 2020, with many companies both in Japan and overseas signing up as members, and specific technological considerations commenced through the use of online video conferencing. Going forward, we will work with a variety of partners for the earliest possible implementation of the IOWN concept.

Three Technologies that Constitute IOWN

- All-Photonics Network
  Photonics technology is applied not only to networks but also to information processing to achieve large-capacity, ultra-low power consumption and ultra-high-speed data transmission that had been difficult in the past.
  We can provide multiple functions that serve as the backbones of social infrastructure without mutual interference by assigning a function to each wavelength on a single optical fiber.
- Digital Twin Computing
  We combine highly precise digital information reflecting real-world objects, such as things, people and societies, to achieve large-scale, high-accuracy predictions and simulations of the future, and enable extremely advanced, real-time interactions between things and people in cyberspace.
- Cognitive Foundation®
  We seek to achieve optimal matching of all manner of ICT resources and distributing necessary information inside the network.

We will lead the shift from a world of electronics to a world of photonics and drive technological development for resolving various global social issues and creating innovative services.

Technology development roadmap for realizing the IOWN concept https://www.ntt.co.jp/news2020/2004e/200416a.html
Formulation of the Digital Twin Computing Initiative https://www.ntt.co.jp/news2019/1906e/190610a.html

Research and Development to Support the IOWN Concept

- By using light as a means for transmitting signals inside the processors that perform information processing and calculations inside a computer, we hope to create a hybrid opto-electrical processor that will solve problems that arise with electrical processing, such as power consumption and increase in heat emission, and realize ultra-low power consumption and high-performance information processing. We have realized ultra-compact photo-electric conversion elements such as an optical transistor that uses nano-photonics technology.
- To conduct a comparative time experiment by connecting several optical lattice clocks that are more precise than atomic clocks, the current standard for measuring seconds, we used the optical fiber network of NTT East for an optical frequency transmission experiment with the University of Tokyo. As a result, the required frequency precision for the comparative experiment was achieved, representing a major step toward conducting the experiment.

Promoting Other Cutting-Edge Research

- In collaboration with the Tokyo Institute of Technology, we achieved an all-optical switch that operates at ultra-high speeds while using the lowest energy consumption in the world. By combining a technology called plasmonics for guiding light into a nano-sized optical pathway with graphene, which has excellent optical properties, we achieved ultra-high-speed switching operation with low energy consumption that exceeds the potential of electronic control. We plan to utilize this technology for ultra-high-speed control of future optical integrated circuits for information processing.
- We successfully developed a method of rebuilding microscopic nerve cell fibers at a micrometer to millimeter scale by forcing graphene, a sheet of carbon material, to spontaneously adapt to a three-dimensional cylindrical structure and culturing nerve cells inside it over a long period of time. This is expected to lead to new bio-device applications such as a fundamental technology for reconstructive surgery using stem cells, a manufacturing technology for the flexible stimulation of electrodes implanted in damaged tissues, and a technology to create tissues for pharmaceutical screening.
- In cooperation with Hokkaido University and the City of Iwamizawa, toward achieving unmanned, fully automated operation in agricultural equipment using remote monitoring, we have started testing an optimal positioning and positional information transmission method, optimal network technology, collection of IoT device data, and AI analysis.
- NTT concluded an agreement with the Japan Aerospace Exploration Agency (JAXA) for implementing an ultra-high-speed, high-capacity, secure optical/wireless network infrastructure to seamlessly connect land and space. In preparation for merging the technologies of both entities to create social infrastructure, the two parties are undertaking joint research in areas such as optical wireless communications in space, next-generation Earth observation, and communication between ground stations and low Earth orbit satellites.
- As part of our efforts to enable communications beneath the surface of the sea where radio waves cannot easily penetrate, we achieved subsurface communication speeds of 1 Mbit/s, a double-digit improvement over current levels by using ultrasound MIMO multiplexing technology to overcome variations in the subsurface propagation path.

NTT R&D https://www.rd.ntt/e/

Intellectual Property Management

Our Approach to Intellectual Property

The business activities of the NTT Group are sustained by products and services derived from the results of our aggressive R&D. For this reason, we believe that appropriate protection and utilization of intellectual property generated by R&D is vital for the NTT Group to achieve continuous growth, which in turn will enable us to continue contributing to our customers and society at large. We strive to protect the intellectual property of the NTT Group and promote activities that respect the intellectual property of others in every aspect of our business activities.

System of Intellectual Property Management

NTT protects the results of its R&D to maintain its competitive edge but at the same time makes its intellectual property available to a wider audience by licensing technologies that would contribute to the development of industries and businesses as well as standardized technologies that are already used in society. Under the leadership of the NTT Intellectual Property Center, NTT has established policies for intellectual property activities involving the entire NTT Group and also provides support and coordination for the use and management of intellectual properties, aggregates the opinions within the Group on the intellectual property system and disseminates information outside the Group.

Protection of Third Party Intellectual Property

In order to prevent the infringement of domestic and overseas third party rights, NTT examines the third party rights of technologies used in our business at every step from the early stage of research and development up to the provision of the developed technologies to Group companies. NTT also strives to enhance the Group's compliance with intellectual property laws and regulations in Japan and abroad and mitigate potential business risks by sharing among the Group companies information on system amendments, and trends concerning intellectual property including disputes and court cases.

NTT Intellectual Property Center https://www.ntt.co.jp/chizai/index.html

External Utilization of R&D Outcomes

Since its founding, NTT has promoted cutting edge technological development as a leading company in the information communication industry. For this reason, we own a vast number of patents.

NTT licenses its proprietary technologies so that they can be used broadly by all for the benefit of the telecommunications market as well as other markets. For example, as part of our initiatives for standardization, we efficiently promote the spread of technology by licensing patents on standardizations to many companies through various patent pools.

- Participation in Intellectual Property Matching Events Organized by Local Governments and Organizations
  In an effort to help vitalize regional business structures, we actively participate in intellectual property (IP) matching events sponsored by local governments to offer licensing agreements that enable local companies to use NTT's proprietary technologies in developing their own products. In the case of a company based in Kawasaki City, Kanagawa Prefecture, we signed a licensing agreement through a matching event organized by Kawasaki City and the Kawasaki Institute of Industrial Promotion that has enabled the company to use NTT's patented technology to provide a new service starting in 2019. We are committed to continue contributing to the vitalization of regional economies through this initiative.

Model for Regional Revitalization through Intellectual Property Matching Events Hosted by Local Governments and Others

- IP Open Access Declaration Against COVID-19
  Recognizing the need to contain the spread of COVID-19, the NTT Group expressed its consistent support for the IP Open Access Declaration Against COVID-19 in May 2020 and declared that it will "not assert any patent, utility model, design or copyright (hereinafter referred to as the "Intellectual Property Rights") against any individual or other entity during the period starting with the date of this declaration and ending on the date on which the World Health Organization declares that the COVID-19 outbreak no longer constitutes a Public Health Emergency of International Concern, with respect to activities whose sole purpose is stopping the spread of COVID-19, such as diagnosis, prevention, containment, and treatment of COVID-19."

NTT discloses its licensing policy and procedures along with detailed information on its R&D activities and technological licenses.

- **R&D Activity** https://www.ntt.co.jp/RD/e/active/index.html
- **NTT Technology Licensing Site** https://www.ntt.co.jp/ntt-tec/e/index.html
- **Licensing policies and procedure** https://www.ntt.co.jp/ntt-tec/e/procedure/index.html
- **Participation in the "IP Open Access Declaration Against COVID-19"** https://www.ntt.co.jp/topics/oacvd19/index.html (Japanese only)