NTT's R&D

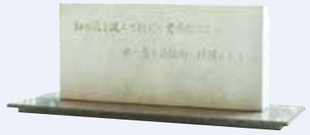
NTT Laboratories, together with the NTT Group and various partners, will continue to engage in world-leading research and development to achieve a sustainable world of well-being.

Overall R&D Strategy

R&D Policy **Do research by drawing from the fountain of knowledge and provide specific benefits to society through commercial development.**

These words, proclaimed in 1950 by Goro Yoshida, the first Director of the Electrical Communication Laboratories under the Ministry of Communications at that time, still live on as the DNA of NTT Laboratories after more than 70 years. They encapsulate the three policies adopted by NTT Laboratories.

1. "Do research by drawing from the fountain of knowledge"	Solidify our position as a world leader in research
2. "Through commercial development"	Quickly and steadily commercialize IOWN and generative AI (tsuzumi)
3. "Provide specific benefits to society"	Provide concrete value by implementing research results in society



In 2023, the NTT Group announced its Medium-Term Management Strategy, "New Value Creation & Sustainability 2027 Powered by IOWN." To make this a reality, we will revisit the core objectives established at the founding of Electrical Communication Laboratories. While reaffirming the importance of research, commercialization, and value provision, we will carry out world-leading research and development with all of our researchers, based on these action guidelines: "Keep our researchers excited and ambitious," "Help society in a scalable and sustainable way with powerful technology," "Create the future rather than just predicting it," and "Hone our intuition and creativity."

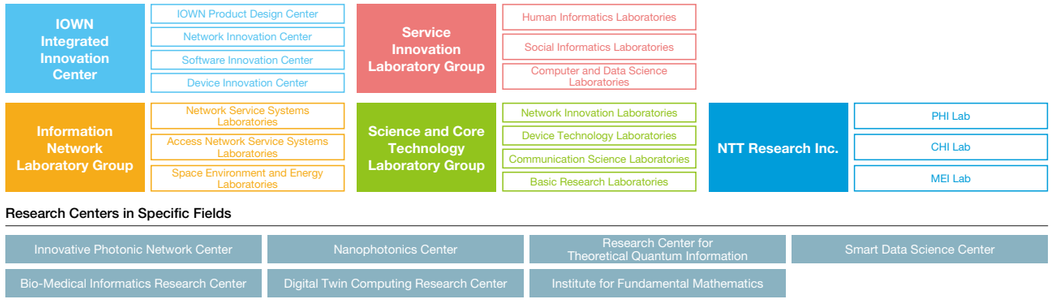
R&D Achievements

Under the NTT R&D vision of developing cutting-edge technologies that contribute to the advancement of society, science, and industry, NTT has approximately 2,300 researchers engaging in a wide range of diverse research activities, from basic research to R&D that supports the business development initiatives of operating companies. We have many researchers who are active on the world stage, including "Fellows," a special position given to researchers whose outstanding research results have received worldwide recognition, and "Senior Special Researchers" and "Special Researchers," which are positions given to innovative researchers recognized for their excellence by the world. Our laboratories are ranked ninth in the world among ICT-related companies in terms of the number of research papers submitted,* a metric for evaluating our level of research. In particular, our research is ranked first or second in the world* in fields such as optical communications, information security, neural engineering, voice recognition, and quantum computing.

This world-class research has been applied in various areas in the ICT field, contributing to promoting innovation and resolving social issues. As an example, our research results in optical fiber and optical communications have led to the high uptake of optical fiber services in Japan. NTT will continue contributing to creating new value through its research and development, which includes fiber optic technologies, the standardizing of fax technologies worldwide, and recognition of IEEE Milestone, proof of NTT's strong international reputation for speech coding.

* Based on NTT research using Web of Science and InCities Benchmarking

R&D Organization

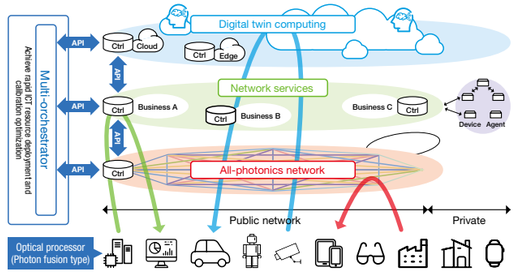


What's IOWN?

IOWN Concept

IOWN is a framework involving devices, networks, and information processing infrastructure built on optical and other innovative technologies, to deliver high-speed and high-capacity communications and vast computing resources. IOWN consists of three key areas of technology: the All Photonics Network (APN), which applies optical technology; Digital Twin Computing (DTC), which enables advanced, real-time interaction between objects and people in cyberspace; and the Cognitive Foundation (CF), which deploys various ICT resources efficiently, including the aforementioned resources.

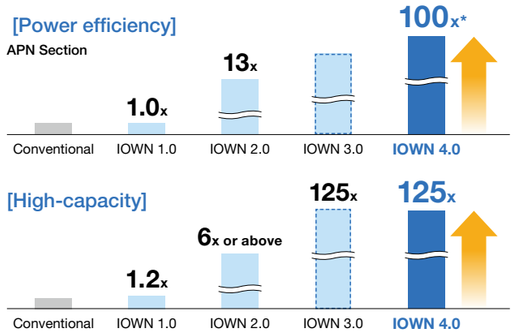
Cognitive Foundation



IOWN Performance Targets

In addition to photonics-electronics convergence devices, we are considering improvements in wavelength technology and optical fiber technology. With IOWN 2.0, we expect a 13-fold improvement in power efficiency in the APN section and an 8-fold improvement in the server section, with a more than 6-fold increase in capacity. With IOWN 3.0, we aim for further performance improvements, reaching up to 125-fold in terms of capacity. The power efficiency depends on the deployment of the device, but its performance will exceed that of IOWN 2.0, and it is expected to improve performance about 20-fold in the server section compared to existing solutions.

Furthermore, we aim to achieve a 100-fold improvement in overall power efficiency, 125-fold in capacity, and 1/200th of the latency with IOWN 4.0.



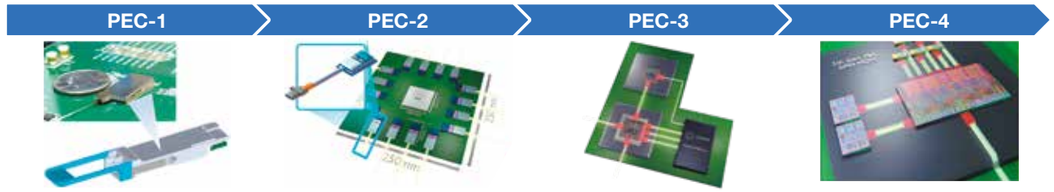
* Power efficiency values for the entire photonics-applied section, including APNs, servers, etc.

Roadmap

Photonics-electronics convergence (PEC) means fusing optical and electrical circuits to achieve various performance improvements, including miniaturization and economization as well as high speed and low power consumption. We aim to apply this not just to networks, but also to the computing realm to significantly reduce power consumption. In fiscal 2022, we commercialized the first photonics-electronics convergence device, PEC-1, which connects data centers to each other.

In fiscal 2025, we plan to commercialize board connection devices (PEC-2), enabling optical connections between boards and between boards and external interfaces. This will allow for the use of optics not only in networks, but also in computing.

Subsequently, with an eye toward fiscal 2028, we plan to make chip-to-chip connections within boards possible using photonics-electronics convergence technology (PEC-3), and beyond fiscal 2032, we aim for connections within the chips themselves to be optical (PEC-4).

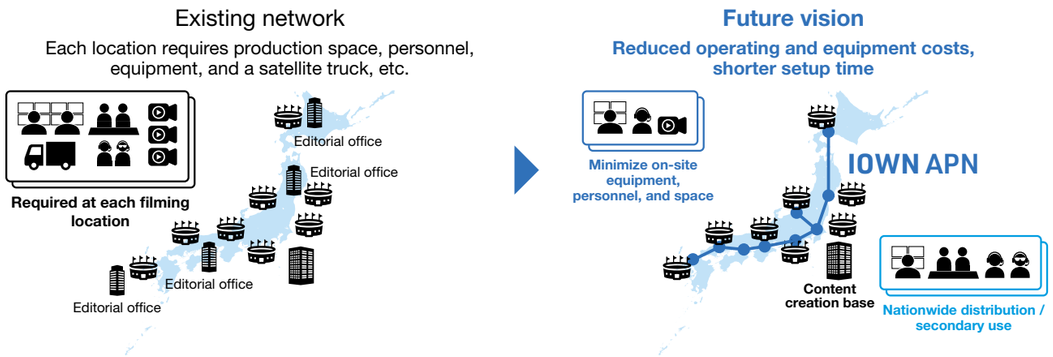


Implementing IOWN in Society

Digital Transformation (DX) in Content Creation

Two pillars support the implementation of IOWN in society: networks and computing. First, we are working to develop a new network called the All-Photonics Network (APN). As well as being the backbone for next-generation data centers, the APN is also being introduced into various fields that benefit from its performance.

In November 2023, we concluded an agreement with Sony Corporation on collaboration and cooperation to accelerate the formation and development of a wide-area remote production platform using the APN. We aim to improve the customer experience by providing highly convenient services, such as content distribution at local stadiums and live music venues that have not been able to receive it previously.



A New Type of Urban Development

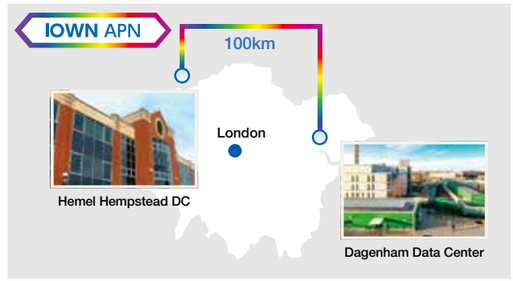
- Tokyu Land Corporation (“Tokyu Land”) and the NTT Group are promoting urban development using the IOWN service in the greater Shibuya area, targeting facilities in which Tokyu Land is involved, as a model area for collaboration.
- In addition to reducing the environmental impact of the greater Shibuya area by reducing power consumption through the IOWN service, we will also position it as a field for social implementation that provides next-generation value, and work to provide new value in line with the future evolutionary steps of the IOWN service. Through these initiatives, we aim to create an environmentally-friendly Shibuya-style urban lifestyle that merges work, life, and play, enabling people to work the way they want, enjoy diverse entertainment, and live in a convenient city full of excitement and relaxation.
- We are currently providing IOWN services for events that introduce IOWN technology and allow visitors to experience its use in urban planning for the future.
- Shibuya “IOWN WEEK” (December 13–15, 2023): Held IOWN entertainment and next-generation remote meeting events (connecting Shibuya Sakura Stage and Shibuya Solasta)

Achieving Distributed Data Centers

Today, there are many places where restrictions on CO_2 emissions, lack of available land, and other reasons make it difficult to build data centers in urban areas, and data centers must be built outside the city. When connecting geographically distant data centers, there is a significant delay in communication between data centers, making it impossible to meet customer demands for low-latency connections.

In April 2024, we conducted demonstration experiments to test the feasibility of APN connections between data centers in Japan and between the U.S. and the U.K., with the goal of achieving distributed data centers. We confirmed that the data centers were connected with a delay of less than one millisecond and delay jitter of less than one microsecond at 400 Gbps, allowing the two data centers, located approximately 100 km apart, to operate as one. We also plan to expand this technology to areas outside of the U.S. and U.K. in the future.

Ashburn (United States)



Hemel Hempstead/Dagenham (UK)

IOWN Global Forum

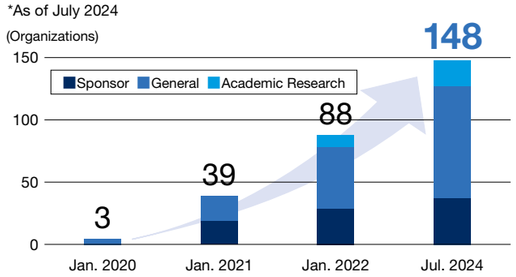
To make the IOWN concept a reality, we have been promoting it around the world with partners through the IOWN Global Forum, and 148 organizations and groups are taking part (as of July 2024).

In December 2023, at the UN International Telecommunication Union Telecommunication Standardization Sector (ITU-T), high-level executives from global carriers, vendors, public organizations, and other attendees acknowledged the value and importance of IOWN and agreed to promote the development of official standards for IOWN technology specifications.

In April 2024, a Japan-U.S. summit was held, after which a fact sheet was released that clearly stated that “U.S. and Japanese companies are exploring the wide range of possibilities available through optical semiconductors through partnerships like the Global Innovative Optical and Wireless Networks (IOWN) Forum.” Thus, the concept is gaining momentum as a key industry.

148 participating organizations and groups, including those from Asia, the U.S., and Europe

*As of July 2024



Efforts for Global Rollout (Upgrade 2024)

In April 2024, the Upgrade 2024 event was held in San Francisco, focusing on issues related to next-generation internet and AI using optical technology, as well as security and privacy challenges.

We promoted our R&D results and advocated the product development of technologies such as APN (distributed data centers) and tsuzumi, with the aim of implementing IOWN in society on a global scale. The in-person event, which included lectures by our partners, was covered by numerous media outlets in Japan and overseas.

AI Initiatives

Commercialization of NTT's Generative AI "tsuzumi"

As stated in the Message from the CTO (P.20) and "Achieving Industrial Transformation through the Promotion of 'Chained AI'" (P.64), the NTT Group has conceptualized a version of chained AI in which multiple small AI models are linked together.

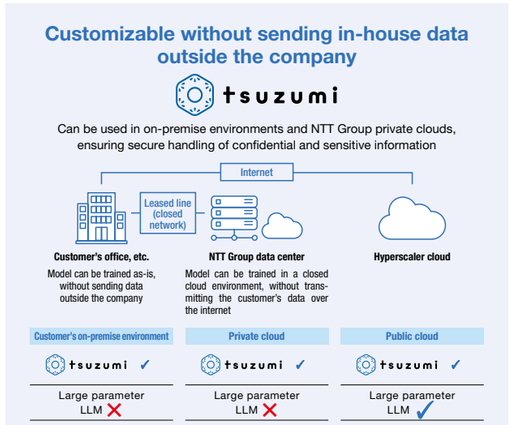
One product developed as part of this concept was NTT's generative AI "tsuzumi," which has high Japanese language processing capabilities and can operate in a secure, closed environment while consuming little power, something not possible with singular giant AI models. We have received more than 650 inquiries about introducing it from various corporate customers and local governments. Two-thirds of the inquiries we receive are from customers who want to use a customized LLM trained on their internal data, with many of these coming from sectors that frequently handle highly confidential data, such as manufacturing, local government, and finance. The primary applications are to improve the customer experience (CX) by using it at customer contact points such as call centers; to improve the employee experience (EX) by streamlining in-house tasks such as automatically creating/summarizing minutes and creating a Q&A list from a business manual; and to automate IT operations and develop software.

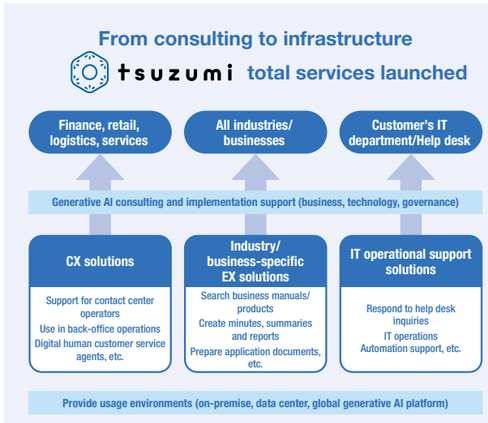
In light of this situation, we announced the launch of "tsuzumi" commercial services that combine three usage environments and three types of solutions in March 2024.

Since "tsuzumi" is lightweight, it can be used on-premise at the customer's office without having to build a large-scale hardware environment, or via a private cloud operated by an NTT Group data center. A customer may also opt to use a public cloud, thereby tailoring the way that "tsuzumi" is used. Using "tsuzumi" in an on-premise environment makes it possible to train the model securely on in-house data without sending the data outside the company.

The three types of solutions are: CX solutions, such as support for operator tasks at contact centers; EX solutions, such as searching through business manuals, creating minutes, and other tasks that require industry-specific knowledge; and IT operations support solutions that support the automation of operations in customers' IT departments and help desks.

In May 2024, we began accepting applications for the "tsuzumi" Partner Program to promote the incorporation of "tsuzumi" in services and the development of industry/business-specific AI models.Together with our partners, we aim to create new services and solutions.





Appointment of Chief Artificial Intelligence Officers (CAIOs)

We have appointed Chief AI Officers to strengthen the use of AI both inside and outside the company. In addition to actively proposing AI to our customers, these officers will be responsible for fundamentally reviewing all our internal business processes and working to automate those that can be handled by AI. To address the risk of social disruptions caused by AI errors and biases, we will establish an AI governance system and promote AI services that customers can use with peace of mind.

Two CAIOs newly appointed to promote the "AI-first" approach

Co-CAIO who promotes the development of AI services and solutions to provide to customers

×

Co-CAIO who implements "AI-first" for all internal business processes while establishing and promoting AI governance

AI Governance

AI Governance Strategy

Technological innovation has led to the rapid permeation of artificial intelligence (AI) into society, and countless AIs are solving issues both large and small every day, without people even realizing it. At the same time, there are also fears that the use of AI could lead to unforeseen forms of discrimination, as well as wrongful guidance or restrictions on actions. In addition, much about AI behavior and its impact is unknown. While expectations for the technology are rising, so are fears, resulting in a need for stronger AI risk management and governance, both domestically and internationally.

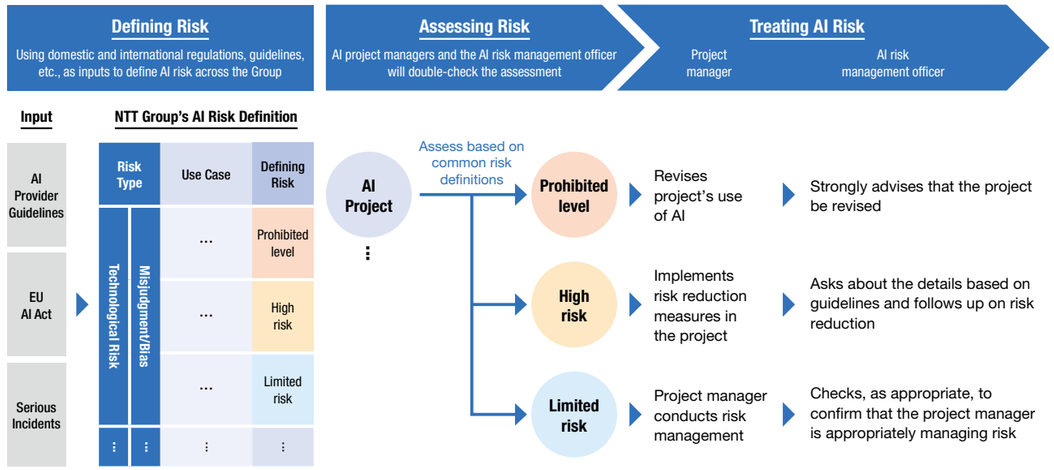
Maintaining a balance between promoting the use of AI and controlling AI risks is extremely important. As we step on the "gas pedal" to rapidly accelerate the use of AI, we are working toward a form of governance that uses both the "gas pedal" and "guardrails" to avoid the kind of critical risks that would cause us to drive off a cliff, rather than hitting the "brakes" to stop progress.

AI Risk Management

It is important for NTT Group companies using AI to manage the risks associated with the inappropriate use of AI, such as violating laws, regulations, or contracts, or being held up to social or ethical critique.

Our method for managing risk is based on the risk-based approach widely adopted in the international community.

Defining AI Risk	We placed the risks associated with the NTT Group's use of AI into the classifications of "prohibited level," "high risk," and "limited risk" for each use case, and applied these definitions across the entire NTT Group.
Assessing AI Risk	Based on the above definitions of AI risk, AI project managers and each company's AI risk management officer will conduct a dual risk assessment in order to ensure an accurate evaluation.
Treating AI Risk	AI projects assessed as having a "prohibited level" will have their method of AI use significantly revised. For projects assessed at non-prohibited levels, each company's AI risk management officer will monitor the reduction of project risk and take courses of action appropriate to the risk while implementing the project.



Strengthening AI Governance

In order to strengthen AI governance, we have referenced the laws, regulations, and guidelines used in international society and those developed by the Japanese government to establish AI governance regulations* that define and manage AI risks in a common way across the NTT Group.

In addition, NTT has appointed Co-CAIOs to ensure that our leadership promotes the appropriate use of AI and exercises control over the NTT Group's treatment of AI risks. NTT has also established an AI Governance Office that assists the Co-CAIOs by maintaining and revising the NTT Group's AI governance regulations, and by monitoring and assessing the state of AI risk management at Group companies.

Each Group company has appointed an AI risk management officer who assesses the risk of AI projects and works to reduce their risks. The Co-CAIOs, AI Governance Office, and AI risk management officer at each Group company will work together to promote appropriate AI risk management and AI governance at the NTT Group.

* The NTT Group AI Charter: A basic policy that the NTT Group and its employees should strive to always keep in mind
The NTT Group AI Governance Policy: A policy that defines AI risk in a common way, establishing how AI governance mechanisms should be maintained and operated in order to implement the appropriate use of AI
NTT Group Guidelines on the Use of Generative AI: Guidelines indicating concrete risks that all NTT Group companies should keep in mind and methods to deal with such risks in order to deter the occurrence of risks involving the use of generative AI and promote the active use of generative AI and value creation

Intellectual Property Strategy

The NTT Group will contribute to the creation of new value and to global sustainability by adequately protecting the results of our investments in intellectual capital as intellectual property while steadily pursuing activities that promote their diverse application.

Approach to Intellectual Property Activities

The NTT Group, which engages in R&D, from basic to applied, in a wide range of technological fields, has accumulated intellectual property investments (R&D investments) over the years as a telecommunications operator that are unparalleled around the globe.

By adequately protecting the results of such intellectual property investments and working to create new value by steadily pursuing activities that promote their diverse application, the NTT Group aims to not only secure its business advantage but also contribute to the enhanced industrial competitiveness of Japan as well as to global sustainability.

The IOWN concept, which has progressed from the planning phase to the implementation phase, cannot be completed by the NTT Group alone. Legal amendments that came into effect this spring have expanded the scope of our use of intellectual property rights more than ever before, facilitating business co-creation. We will contribute to the creation of new value by utilizing the intellectual property rights we have accumulated over many years in a diverse and timely manner, while supporting collaboration with our partners from a global perspective.

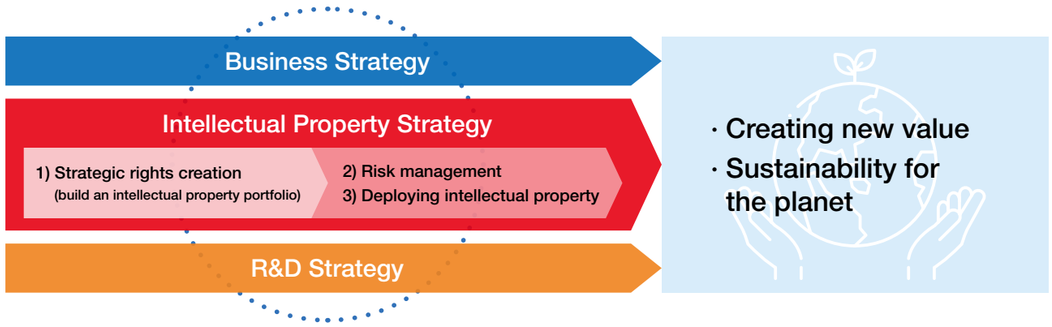
Formulating and Advancing Our Intellectual Property Strategy

As NTT Group's core organization for managing intellectual property, we aim to secure competitive advantages by proactively and appropriately protecting and managing intellectual property rights (i.e., patents), or internal expertise, gained from the results of R&D, the source of our business activities.

NTT aims to share the benefits of its R&D by broadly licensing out its technologies that help advance industry and technologies that can be standardized and used throughout society. When deploying the results of R&D in their operations, each company in the NTT Group respects the intellectual property rights of other companies.

With our intellectual property strategy as the basis of these activities, we take a three-pronged approach to formulating and advancing our business strategies and R&D strategy for the sake of creating new value and contributing to the sustainability of the planet: (1) develop strategic intellectual property rights, (2) manage risks, and (3) deploy the intellectual property we own.

(1) Strengthening our competitiveness with strategic rights creation (build an intellectual property portfolio)	· Build an intellectual property portfolio through the strategic development of intellectual property rights from fruits of R&D activities, based on technologies and anticipated business models
(2) Risk management that protects our intellectual property rights and respects the rights of others	· When Group companies deploy the results of R&D in their operations, we examine the intellectual property rights of others inside and outside Japan up until the stage where R&D results are applied in order to avoid infringing on the rights of third parties · Reduce business risk and comply with laws and regulations related to intellectual property rights, by sharing among Group companies information about intellectual property trends and their impact, such as revisions to systems around the world, cases of conflict, and court decisions
(3) Develop business and partners through broad deployment of intellectual property rights	· Deploy intellectual property in business to help our customers and society, and to secure competitive advantages in business · Proactively engage in activities to standardize intellectual property



Activities to Promote the Diverse Application of Intellectual Property

At NTT, we use intellectual property rights not only to secure the Group's business advantage, but also to contribute to the development of industries. By exhibiting technologies at intellectual property business matchmaking events held by local governments, etc., we support the development of new products and the creation of new businesses by SMEs and startup companies, thereby accelerating the social implementation of these technologies and contributing to the development of industries in Japan.

In fiscal 2023, we exhibited at two intellectual property business matchmaking events to introduce our R&D technologies. We are also moving forward with the commercialization of NTT's patented technology at companies that we matched with at the event in fiscal 2022. We held one-on-one meetings with SMEs that expressed interest in the anti-rust coating technology developed by the R&D department and provided support for the introduction of this technology.

The NTT Group will continue to contribute to the creation of new value through initiatives aimed at building a co-creation ecosystem with our customers, partners, and startups, including participation in intellectual property business matchmaking events.

Winner at the FY2024 Intellectual Property Achievement Awards (JPO Commissioner's Award) Presented by the Japan Patent Office of the Ministry of Economy, Trade and Industry

NTT Communications, which manages the "docomo business" brand of the DOCOMO group, received the JPO Commissioner's Award (for a company that promotes open innovation) at the FY2024 Intellectual Property Achievement Awards held on April 18, 2024 by the Japan Patent Office and Ministry of Economy, Trade and Industry.

Through programs such as the Business Co-Creation Program, NTT Communications is working with a variety of companies on co-creation activities aimed at creating new businesses and implementing new technologies in society. This award was given in recognition of NTT Com's company-wide measures for open innovation and intellectual property activities that promote co-creation.

NTT Named an Asia IP Elite Organization in 2023

NTT has been named one of the "Asia IP Elite 2023" selected by *Intellectual Asset Management (IAM)*, an international intellectual property-related information publication. *IAM* awards this title to companies with the best intellectual property strategy among companies selected from all over Asia that are actively involved in IP utilization and disputes resolution. This international award was given in recognition of the NTT Group's advanced R&D efforts and innovative approach to maximizing the value of intellectual property, including the active utilization of patents created by the Group.

IPR*-DAY (Initiative for Raising Interest in Intellectual Property Across the Group)

NTT has been holding a cross-Group comprehensive event known as IPR-DAY since fiscal 2022, with the aim of elevating the level of interest in intellectual property among Group employees and helping them integrate this knowledge into their daily work.

IPR-DAY 2023, conducted in November 2023, saw the participation of 550 individuals from 63 Group companies, covering a diverse range of professions. During the event, lively discussions took place on timely topics provided not only by the NTT Intellectual Property Center, but also by intellectual property managers from various Group companies, leading to a significant rise in interest and understanding of intellectual property across the NTT Group.

*Intellectual Property Right

IPR-DAY 2023 Program

- Reading and understanding the business strategies of competitors through IP analysis
- OneNTT's IP activities aimed at realizing the IOWN concept
- A year of IP work at NTT Communications by someone with no prior experience
- Why NTT obtains patents
- Building Bridges Worldwide: Activities of IP Utilization
- AI technology innovations shaking up 500 years of IP history: The future of IP law we need to know in preparation for future business