Report on NTT R&D FORUM 2024 - IOWN INTEGRAL

NTT R&D Forum Secretariat

Abstract

The "NTT R&D FORUM 2024 - IOWN INTEGRAL" was held from November 25th to 29th, 2024. This article presents an overview of the Forum.

Keywords: R&D Forum, IOWN, artificial intelligence

1. Introduction

The "NTT R&D FORUM 2024 - IOWN INTEGRAL" was held over five days from November 25th to 29th, 2024. The Innovative Optical and Wireless Network (IOWN), a next-generation information and communications infrastructure centered on optical technology, is steadily expanding from networks to artificial intelligence (AI), and continues to evolve toward the creation of a sustainable future society. The theme of the Forum was "Integral," which can mean both "integration" and "indispensable." We incorporated these two aspects to symbolize the evolution of IOWN. "Integration" means that IOWN will be applied and integrated to various fields and "indispensable" means that IOWN will become indispensable to the Earth and humanity.

Three people took to the stage for keynote speeches: Akira Shimada, president and chief executive officer (CEO) of NTT Corporation, Shingo Kinoshita, senior vice president, head of research and development planning of NTT Corporation, and Katsuhiko Kawazoe, senior executive vice president, chief technology officer (CTO) of NTT Corporation. Two technical seminars were held. The first seminar featured a panel discussion on the theme of "Next Generation AI," bringing together experts from NTT, the University of Tokyo, Sakana AI, and the technology magazine WIRED Japan to discuss the direction in which AI should evolve. They confirmed the importance of collaboration, such as "moving from a single large-scale AI to the combination of multiple specialized AIs." Under the theme of "The Future of Photonics-Electronics Convergence Technology and Supercomputers," the second seminar included a dialogue between the representative of Preferred Networks (a company that has received acclaim for its exploration and achievements in deep learning software technology and computing infrastructure technology) and an NTT researcher who aims to solve societal problems using photonics-electronics convergence (PEC) devices, starting with "reduced power consumption in the age of AI" and touching upon the very essence of computer architecture. Both the keynote speeches and technical seminars were a great success, with attendees exceeding the capacity of the venue.

The technical exhibits were divided into three areas: "RESEARCH," "DEVELOPMENT," and "BUSINESS." They were arranged thematically on the basement, first, and second floors of the venue site, allowing visitors to view the entire exhibition in a systematic manner. Exhibits were colored blue in the RESEARCH area, green in the DEVELOPMENT area, and purple in the BUSINESS area, allowing visitors to understand the relationship between the areas at a glance.

The Forum was organized as an invitation-only event by NTT Group companies and was attended by a total of 19,261 people, exceeding the previous year's attendance. The Forum closed to great acclaim,

with high expectations for the IOWN future. We report on this event.

2. Keynote Speeches

2.1 Keynote Speech 1: Addressing Social Challenges with Industry AI Cloud Powered by IOWN

In his keynote speech, NTT President and CEO Akira Shimada touched on the rapid spread of generative AI and its impact while discussing the current state and challenges of AI use in companies, as well as new solutions proposed by NTT (**Photo 1**).

While more than 90% of companies in the United States have adopted AI, the figure is still only around 60% in Japan. Even in companies that have adopted it, it is primarily being used for general-purpose tasks, and fundamental changes such as expanding it to more specialized tasks or creating new services are yet to come. Given this backdrop, President Shimada proposed the Industry AI Cloud concept as a platform for using AI for highly specialized tasks in each industry. Specifically, he introduced efforts to create a society with zero traffic accidents in collaboration with Toyota Motor Corporation and the creation of a virtual wholesale market for agricultural product trading to optimize the entire food and agriculture value chain. In August 2024, NTT established a new company, NTT AI-CIX, which aims to achieve industry-wide transformation using AI technology. The company has begun collaborating with Trial, a nationwide supermarket chain, to optimize supply chains in the retail and distribution industries. They are working to optimize areas such as shelf-layout optimization and automated ordering.

On the other hand, the increased use of AI raises concerns about the issue of electricity. With an increase in power consumption on the horizon, NTT is working to advance its low-power, lightweight AI model "tsuzumi," and to promote IOWN, which will create a low-power computing infrastructure.

Of particular note, President Shimada announced that NTT aims to construct a data-centric infrastructure (DCI) that incorporates PEC devices in IOWN 2.0, which will be launched in 2025. At the NTT Pavilion at the Expo 2025 Osaka, Kansai, Japan, NTT plans to implement a server that aims to reduce power consumption to 1/8th the current level and provide an opportunity for visitors to try it out. He also unveiled an ambitious roadmap of IOWN toward the commercialization of this server in 2026, optical communication between chips in 2028, and optical communication inside chips from 2032 onwards, ultimately aiming to reduce power consumption to 1/100th of the current level.

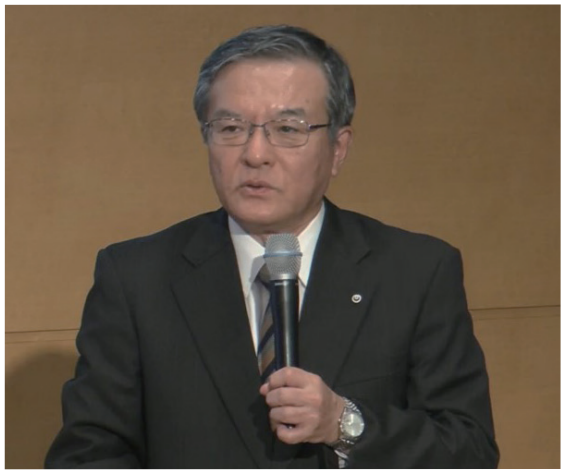

Photo 1. Akira Shimada, NTT president and CEO.

The keynote speech emphasized NTT's vision of combining the Industry AI Cloud with IOWN to solve real-world problems in a sustainable manner. It presented a concrete and achievable vision of the future, in which AI is increasingly used in the highly specialized areas of each industry while providing solutions to the problem of increasing power consumption.

2.2 Keynote Speech 2: IOWN INTEGRAL

NTT Senior Vice President Shingo Kinoshita began his keynote speech by presenting an overview of the Forum and the IOWN roadmap (**Photo 2**). The latter in particular demonstrated the gradual adoption of optical technology from IOWN 1.0 in the networking domain to the computing domain. The next version, IOWN 2.0, will implement optical wiring between server boards, IOWN 3.0 will implement it between packages, and IOWN 4.0 will implement it inside chips, tracing a steady path of evolution.

He also reported on the progress of the All-Photonics Network (APN) in the current IOWN 1.0. NTT EAST and NTT WEST have upgraded the APN IOWN 1.0 service, which was launched in March 2023, to guarantee bandwidth of up to 800 Gbit/s, the world's highest level, expand its interface, and significantly reduce power consumption. The provision of this new APN service began in December 2024. A proof-of-concept experiment demonstrating APN's low latency of just 17 ms over a long-distance

Photo 2. Shingo Kinoshita, NTT senior vice president, head of research and development planning.

Photo 3. Katsuhiko Kawazoe, NTT senior executive vice president and CTO.

connection of approximately 3000 km between Japan and Taiwan was also presented. He also mentioned ultra-fast data backup using the APN and highly efficient remote production through the APN. He also revealed that NTT aims to achieve unparalleled transmission capacity and power efficiency through on-demand optical path control, which will enable multiple wavelengths to coexist within a single APN line without colliding with each other.

Senior Vice President Kinoshita also introduced advances in NTT's large language model (LLM) "tsuzumi." While maintaining its light weight and ability to run on one GPU and one CPU, tsuzumi has steadily improved in performance, including multimodal support and improved contextual understanding. Of particular note is that tsuzumi has been adopted by Microsoft Azure and Salesforce platforms, marking the first step toward global expansion. He also touched on examples such as the AI agent function for controlling a personal computer on behalf of the user and demonstrated part of a vision for coexistence with humans and AI where tsuzumi is used, including the implementation of the *AI constellation* that combines multiple LLMs to solve real-world problems.

To conclude his keynote speech, he quoted Goro Yoshida, the first director of the Electrical Communication Laboratory (predecessor organization of NTT laboratories): "Do research by drawing from the fountain of knowledge and provide specific benefits to society through commercial development." He emphasized the importance of a consistent approach across research, development, and social implementation and laid out three commitments: to establish its position as one of the world's best research institutes, ensure the commercialization of IOWN, and achieve social implementation with value.

2.3 Keynote Speech 3: Unlimited Innovation for a Global Sustainable Society by IOWN

NTT Senior Executive Vice President Katsuhiko Kawazoe gave a presentation in English about NTT's current status as a global company and its key technologies (**Photo 3**). He explained how the NTT Group has evolved into a global corporation with over 900 companies worldwide, with 45% of its employees working outside Japan, and that it has 17 research laboratories with 2300 researchers engaged in cutting-edge research and development (R&D).

He noted that while enhancing information and communication technology (ICT) is essential in light of the crises modern society faces, such as climate change, natural disasters, and a divided world, there is also a new challenge: a sharp increase in electricity consumption due to an explosive increase in Internet traffic. He also introduced the prediction that data-center power consumption will increase 13-fold by 2030. Senior Executive Vice President Kawazoe emphasized that IOWN is NTT's concept for overcoming the limitation of current technology to reduce power consumption and that optical technology is the key. In 2019, NTT succeeded in developing the world's first optical transistor, and this invention

Photo 4. (From left) Michiaki Matsushima, head of editorial content, WIRED Japan; Susumu Takeuchi, senior research engineer, supervisor, NTT Computer and Data Science Laboratories; Ren Ito, co-founder and COO, Sakana AI; and Yoichiro Miyake, project professor, Institute of Industrial Science, The University of Tokyo.

became the origin of the IOWN concept.

He highlighted several use cases as examples of new capabilities that IOWN will bring. One of these is the use of AI to combat new cyber-security threats. Against attacks that combine botnets and advanced AI, he proposed a form of defense in which multiple AIs work together on the IOWN APN to respond to them immediately.

He also touched on NTT's efforts to create a society with zero traffic accidents in collaboration with Toyota. He made it clear that they aim to build a safe mobility society by combining three core technologies: the intelligent communication infrastructure for real-time data collection, decentralized computing infrastructure for constant connectivity with datacenters, and the Mobility AI Platform for learning from diverse data.

He also unveiled NTT's vision for expanding IOWN's capabilities from the ground to space. He said that by collaborating with SKY Perfect JSAT, they aim to build an independent network system in space, the Space Integrated Computing Network, that can instantly process and analyze data from observation satellites in space.

To conclude his keynote speech, he spoke about the capabilities that IOWN opens up for humanity, illustrated by a project to support the work of a DJ with ALS (amyotrophic lateral sclerosis). "Human potential is infinite," he said, sharing with the audience his thoughts on creating a sustainable society.

3. Technical Seminars

3.1 Technical Seminar 1: Next Generation AI

Moderated by Michiaki Matsushima, head of editorial content of WIRED Japan, the panel discussion included Yoichiro Miyake, a project professor of the Institute of Industrial Science, the University of Tokyo, Ren Ito, co-founder and chief operating officer (COO) of Sakana AI, and Susumu Takeuchi, senior research engineer at NTT Computer and Data Science Laboratories. They engaged in a lively discussion about the limitations of current LLMs and their future prospects (**Photo 4**).

At the beginning of the session, Mr. Matsushima introduced the term "technodiversity" proposed by a Hong Kong philosopher Yuk Hui and framed the discussion with the question from Ken Suzuki, chairman of SmartNews: "how is it possible to live in a complex world while maintaining complexity."

In response, Mr. Takeuchi, based on the premise that a "silver bullet" technology probably does not exist, touched on the possibility that NTT could find new ways to use AI by using reasonable LLMs with expert knowledge that are superior in terms of computational costs and power consumption and by creating an AI constellation that allows different LLMs to discuss with each other.

Mr. Ito expanded on the discussion, presenting Sakana AI's "evolutionary model merge," which he described as "the embodiment of the concept of the AI constellation" that connects small language models to achieve performance comparable to LLMs. Researchers at Sakana AI combine existing models using the method called "Frankenmerging" to create 10,000 models, select the top 10 models among them and discard the rest then combine these 10 models to create another 10,000 models, which become the second generation of the model. By repeating the process over multiple generations, they were able to create a model with performance equivalent to GPT-3.5 in just 24 hours and with 24 dollars. He also

presented the application of their AI technology to workflow automation that automates multi-step processes. They succeeded in automating the entire process of writing a science paper, from generating an idea, executing experiments, paper writing, and peer review. This was the first AI-based achievement to be featured in Nature magazine, attracting a great deal of attention.

From the perspective of expanding AI models, Mr. Miyake presented three important categories based on his experience developing game AI: the *meta AI* that controls the game as a whole, *character AI* that acts as the brain of the character, and *spatial AI* that assists with real-space recognition. What is particularly noteworthy is that these AIs go beyond simple uses within games; they also contain implications for urban design and the creation of smart cities. For example, a cyclical approach in which information from real space is collected and analyzed using a digital twin, and the results are then fed back into real space, should strongly boost future urban development.

In the second half of the session, there was an in-depth discussion about the direction AI is evolving. Mr. Ito pointed to the improvement of *reasoning* abilities (logical thinking and inference) as an important turning point in the current development of AI and noted that this will be the key to enabling AIs to interact with each other and conduct simulations. He also predicted that the first stage in using AI would be to improve task efficiency, followed by a stage where it would be used as a sounding board to bounce ideas off.

Mr. Miyake made an interesting proposal regarding the possibilities of using AI to simulate meetings. He suggested the potential for AI to exhaustively simulate options and branching points that are often overlooked in traditional meetings, supporting better decision-making. He presented the possibility of a new approach in which AI would hold a meeting before the actual meeting then humans would hold a discussion on the basis of the results.

Regarding the future relationship between AI and humans, Mr. Takeuchi pointed out that there is an affinity between the existence of diverse AIs and the Japanese concept of "eight million gods." He envisioned a future in which AI with a variety of roles will be omnipresent and coexist with humans. He emphasized that with generative AI technology, system integration that has previously only been discussed theoretically is now becoming a reality with more concrete and advanced services.

What emerged from the discussion among the three panelists was the form that next-generation AI should take. This future will not be dominated by a single large-scale AI. Instead, AIs with a wide variety of expertise will work together to support human creativity and jointly seek solutions that embrace diverse values and perspectives.

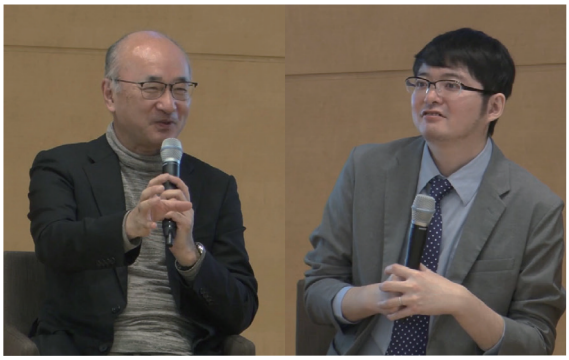

Photo 5. (From left) Shinji Matsuo, NTT fellow, NTT Device Technology Laboratories/NTT Basic Research Laboratories; Toru Nishikawa, representative director & CEO, Preferred Networks.

3.2 Technical Seminar 2: The Future of Photonics-Electronics Convergence Technology and Supercomputers

In a seminar held by Shinji Matsuo, NTT fellow at NTT Device Technology Laboratories and NTT Basic Research Laboratories, and Toru Nishikawa, representative director & CEO of Preferred Networks, a discussion was held on the direction of technological innovation to address the issue of increasing power consumption (**Photo 5**).

First, they gave presentations based on their companies' initiatives. Mr. Matsuo pointed out that datacenters currently account for 2% of the world's power consumption and 12% of power consumption in Japan's Tokyo metropolitan area. He also mentioned that the NTT Group itself consumes approximately 0.7% of Japan's total electricity, emphasizing the need to reduce power consumption. He demonstrated the potential of optical technology as a solution.

He explained that advances in optical technology, such as on-chip PEC technology, will enable "miniaturization, low power consumption, and low cost," making it possible to significantly reduce power consumption. He presented benefits of introducing inter-chip optical interconnection, including faster data communication speeds while reducing power

consumption, ensuring power allocation for computation, and making effective use of computing resources independent of the physical location of the hardware, along with a specific technical path to get there.

Mr. Nishikawa, who aims to "commercialize cutting-edge technology in the shortest possible time," spoke about the challenges facing computing infrastructure in the age of generative AI. Citing the example of the "MN-Core" processor that his company is developing, he explained how a significant improvement in power efficiency was achieved by focusing on the computing unit and on-chip memory and minimizing control circuits. Supercomputers equipped with "MN-Core" have been ranked number one in the world three times in the energy-efficient supercomputer ranking "Green500," and Preferred Networks is continuing to further develop its architecture with confidence. He also revealed their development plans for next-generation processors that will use different optimal architectures for inference and learning. He stressed the importance of creating a "new computer" by integrating various technologies such as interconnects and chiplets, not just highly efficient AI chips.

Following the presentation, a more specific discussion about computing architecture in the AI era took place. What attracted particular attention was the potential and challenges of distributed computing. While Mr. Matsuo pointed out that optical technology can be used to connect memory up to 2 km away without any loss, he also hinted at physical constraints, stating that some delay is unavoidable. Given that current supercomputers are limited to connections within 10 m, he asked a fundamental question: "Can a supercomputer that takes up an entire datacenter really be used for AI?"

Mr. Nishikawa responded by proposing a new approach that uses AI in the design of a supercomputer, stating that as supercomputer systems become more complex, they are becoming increasingly difficult for humans to design accurately. However, he also said that it is difficult to design complex circuits from the start and emphasized the need to develop circuits gradually, starting with small ones.

Opinions were also exchanged about the future of packaging technology. Mr. Nishikawa explained that next-generation processor development requires a high-density, high-efficiency design that separates inference and learning and emphasized the particular challenge of dealing with heat dissipation.

At the end of the discussion, they offered messages to young researchers. Mr. Matsuo stated that "it is important to take into account the entire planet and society as a whole," and expressed his enthusiasm for "creating a world where energy savings can be achieved through AI." Mr. Nishikawa concluded by reaffirming the importance of comprehensive R&D such as that carried out by NTT, stating, "Understanding and integrating both hardware and software make it possible to achieve revolutionary innovations that could not be achieved by either one alone."

4. Technical Exhibits

4.1 Technical Exhibits: RESEARCH

In the RESEARCH area, 49 exhibits showed NTT's latest basic research achievements in the fields of network, user interface/user experience, sustainability, security, bio/medical, and quantum computing. Exhibits of technologies progressing toward practical application drew the attention of visitors in particular. These included technologies for a novel quantum computer, non-invasive wearable glucose sensor, and active noise cancellation.

(1) Optical technologies for optical quantum computing with continuous variables

Progress is being made in the research of quantum computers, which leverage quantum properties to solve computing problems that are difficult to solve with conventional technologies. While there are various methods, superconducting quantum computing and neutral atom quantum computing, considered the most mainstream methods, require an environment cooled to near absolute zero (–273°C) for stable operations. Thus, they face the issue of limited chip scaling because the chips must be cooled.

NTT is engaged in R&D to develop continuous-variable optical quantum computers. Using the company's cultivated high-performance optical device technologies, this quantum computer is capable of large-scale calculations at room temperature. Technologies used in optical fiber communication can be applied to many of the elements that make up the continuous-variable optical quantum computer. When new technologies are needed, extending optical device technologies cultivated by NTT holds great promise. Integrating optical communication technologies and optical quantum technologies makes it possible to achieve large-scale calculations at a bandwidth 1000 times that of conventional computers, even at room temperature. This achievement heralds the arrival of innovation in the field of

Fig. 1. Demonstration of the optical quantum computer linked between RIKEN and NTT.

quantum computing.

For this exhibit, Professor Akira Furusawa of the Graduate School of Engineering at the University of Tokyo, whose lab is collaborating in the development of this quantum computer, participated. A demonstration connecting RIKEN, where the developed computer is installed, and NTT was carried out for the first time (**Fig. 1**).

The continuous-variable optical quantum computer is expected to be applied to optimization problems, which seek solutions that maximize or minimize the objective function from a vast number of choices while satisfying constraints, and to neural networks. This computer is considered particularly advantageous compared with conventional computers for problems that deal with continuous data and systems.

The exhibit also touched on the development of a system that places a cloud between users and the quantum computer. It sends specified parameters to the quantum computer and sends the results of the job executed by the quantum computer to the user, enabling the creation of a more convenient quantum computing environment.

Applying optical devices developed by NTT, we anticipate developing a rack-sized optical quantum computer around 2030 and chip-based optical quantum computer around 2050.

(2) Non-invasive wearable glucose sensor using microwaves

NTT is advancing R&D in the biomedical field using its sensor and data-collection technologies. The goal is achieving precision medicine, which enables total medical care, including health promotion, preventive medicine, treatments, and prevention of worsening of illnesses, tailored to each individual.

One R&D achievement is a glucose sensor that carries out measurements using microwaves. NTT is aiming to commercialize this sensor by FY2028. Conventionally, a person's glucose level, which reflects the amount of sugar in the bloodstream and a factor related to diseases such as diabetes, is measured by sticking a disposable sensor into one's body with a needle. However, this method is highly burdensome for users, as it brings pain and discomfort. The barrier to its use is an issue.

To solve this problem and enable visualization of a person's glucose level without using needles, NTT is developing a non-invasive sensor in wearable form that makes contact with the skin and carries out measurement using microwaves (**Fig. 2**). NTT has many types of equipment for evaluating the response of different microwave frequencies in communication devices and has identified frequencies that are highly responsive to glucose.

NTT is conducting trials on glucose measurement while the user is at rest. Going forward, our goal is to enable convenient visualization of changes in the glucose level on a daily and constant basis by researching and developing technologies to suppress error factors. Our glucose-sensor technology promises to contribute to supporting appropriate dietary guidance and exercise regimen to prevent an increase in glucose levels.

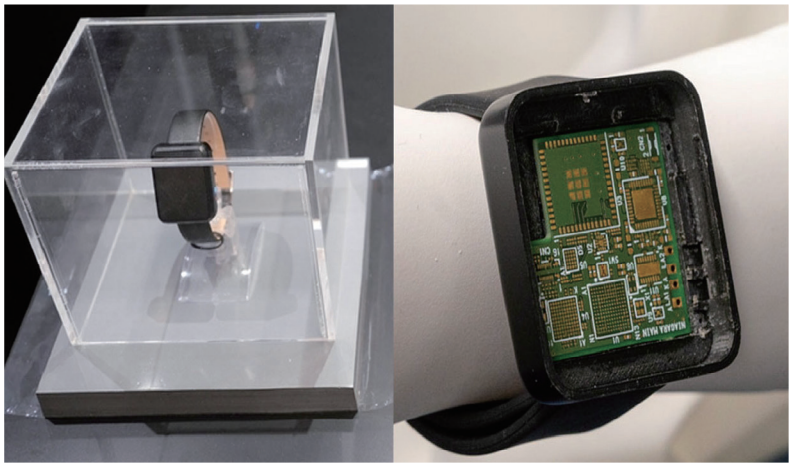

Fig. 2. Wearable glucose sensor under development to be even smaller.

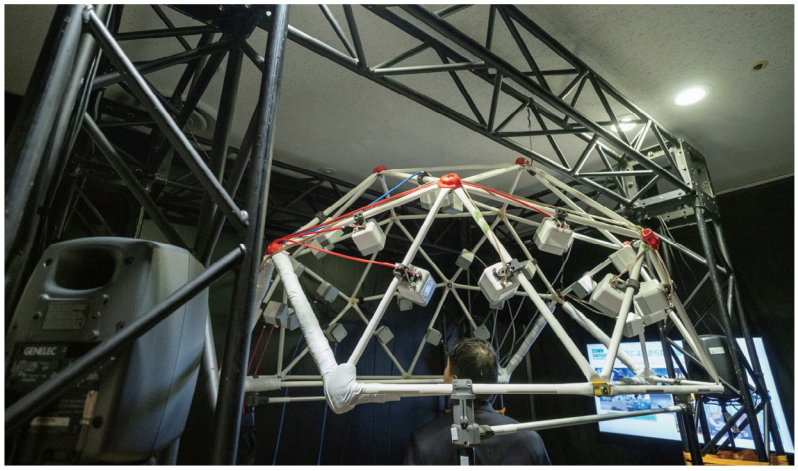

Fig. 3. Dome-shaped noise-cancelling system.

(3) Personalized Sound Zone (PSZ)

NTT is pursuing a variety of R&D initiatives to achieve the "ultimate private sound space" where users hear only the sounds they want to hear and allow others to hear only the sounds they wish for them to hear. We are developing and selling earphones and headphones that enable users to hear sounds without the phones blocking their ears. These products provide optimal sound control tailored to each individual with functions, such as noise cancellation, and benefits such as increasing value at performance venues. NTT seeks to enhance customers' experience based on sound.

The exhibit at NTT R&D Forum 2024 provided several experiential programs. When guests enter a sound dome, noise is eliminated using several noise-cancelling speakers (**Fig. 3**). We envision the use of this system in entertainment venues and general business facilities. The exhibit depicts a vision of the future where users can simply sit at a particular table and easily converse without environmental noise.

The demonstration of the Sound SyReal technology combined sounds in cyberspace and sounds in the real space. Sounds flowing into the participants' earphones and sounds flowing in the exhibition venue were adjusted in real time using low-latency transmission technology. Participants experienced the acoustic effect of hearing sounds from behind them,

Fig. 4. New Visual Comprehension Adapter added to tsuzumi.

even though no speakers were placed there. Another demonstration presented *acoustic cross reality*. Using the aforementioned open-ear headphones, particular sound effects can be played for only audience members watching a play as well as render real sounds on the stage clearer.

The exhibit also presented technologies for precise control of sound, enabling users to not only spend time with peace of mind and security in a world where people and noises are mixed but to also experience increased value in all types of venues.

4.2 Technical Exhibits: DEVELOPMENT

In the DEVELOPMENT area, 52 exhibits, including exhibits on NTT's latest IOWN-related research initiatives and practical applications, generative AI, and space technologies were presented. Examples include the collaboration between humans and AI based on NTT's evolving LLM "tsuzumi," media production digital transformation (DX), which enables networking, sharing, and cloud computing of video-production equipment using IOWN-related technologies, and innovative technological developments such as the NTT Group's space business brand "NTT CONSTELLATION 89 PROJECT (NTT C89)."

(1) The evolution of tsuzumi: NTT's large language models

As can be understood from the exhibit's key message "Empowering Business and Life with a New Level of Comfort through tsuzumi," the biggest difference from the previous year's tsuzumi exhibit is the addition of a technology to leverage tsuzumi in practical applications. This technology is the Visual Comprehension Adapter (**Fig. 4**). Documents, such as web pages and PDFs, contain not only text but also images and diagrams, the layout of which holds meaning. The exhibit presented visual comprehension technology that enables the meaning of a document as a whole to be understood.

The exhibit demonstrated tsuzumi's automation of the creation of order slips for desired products as an example of intra-company DX made possible by tsuzumi. The tsuzumi LLM successfully created the order slips by referencing internal work manuals while operating the actual system screen.

Many data and information technology systems created for human use become difficult to operate due to their age and the technologies used in their creation, becoming burdens in daily life and work. In places such as large corporations and government agencies where large-scale system upgrades require time and capital expenditure, legacy technologies are kept in use through extensions. Against the conventional approach to upgrade enterprise systems, tsuzumi shows the way to new business transformation thanks to its ability to understand and execute operations on current systems. Furthermore, tsuzumi is continuing to evolve as it facilitates collaboration between humans and AI through information acquisition and assimilation by means of natural human dialogue and response and document comprehension.

(2) IOWN × Media production DX

The proliferation of Internet media has brought

Fig. 5. Production of TBS Television's program at the Musashino R&D Center.

about intensified competition among video-content companies. Media production DX using the IOWN APN promises to address the need to develop high-quality content and improve operational efficiency. The exhibited technology uses the IOWN APN to implement a wide-area network spanning multiple locations to connect a large number of shooting sites and production bases. The IOWN APN is ideally suited because it features high capacity, low latency, and no jitters. For example, to broadcast live sports, staff and a production truck loaded with production equipment were dispatched to the event. Using the IOWN APN, however, makes it possible to directly transmit source video from the event site to a private cloud and edit the video in real time in a studio at a separate location.

At this exhibit, media content production environments that may become the new standard were presented. These include broadcasting a TBS Television's program from the Musashino R&D Center with video switching and mixing (**Fig. 5**) and activating an international IOWN APN spanning 3000 km by connecting to Chunghwa Telecom in Taiwan.

(3) New wireless energy transmission technology

The NTT Group has launched the NTT C89 brand for its space business and industry and is engaged in creating space services and addressing global issues such as climate change. As the cost of launching satellites and rockets fall, businesses and services making use of outer space have increased. One such service is planetary survey by using a rover. This planetary-exploration hardware is indispensable for space exploration. Wide-area surveys by a rover can be carried out either through automation or remote control, making it an important partner in advancing exploration of the lunar surface. However, there is drastic environmental difference between "daytime" on the moon, during which the surface temperature rises to 110°C, and "nighttime," during which the surface temperature falls to –180°C. This presents a barrier to using rovers, as it is difficult to use batteries as a power source and costly to transport power cables from Earth.

NTT has thus developed a method for supplying stable power wirelessly to the rover, unaffected by the surface temperature or sunlight on the moon. This method transmits highly efficient, contactless energy using materials that can be procured from the lunar surface. Power is sent to a rover equipped with a receiver from the transmitter. The transmitter, which includes a proprietary field resonance antenna that generates strong electric field waves, uses lunar sand called regolith as the transmission path (**Fig. 6**). Compared with conventional methods, such magnetic resonance or microwaves, the surface area for transmission is expanded by more than 100-fold and the transmission efficiency by more than 10-fold. Put another way, the technology constructs a lunar-surface power-transmission network using lunar regolith. NTT seeks to apply this technology not only to exploring the moon but also to provide power to space elevators from 2050 onward.

4.3 Technical Exhibits: BUSINESS

In the BUSINESS area, NTT Group companies

Fig. 6. Supplying power to a rover equipped with a receiver by using lunar sand as the transmission path.

showed their initiatives in applying R&D results to actual business through 21 exhibits. Their efforts were divided into three categories: communication & computing, CX (customer experience) & DX, and security & privacy. Socially implemented technologies directly connected with commercialization were introduced, including the rectification of urban road traffic using NTT's 4D digital platform™ to reduce social burden and trust technology that can verify the authenticity of data.

(1) 4D digital platform™ technologies boost society DTC

The use of digital twins as a method for approaching real-world problems is growing. The technology reproduces real-world objects and conditions and monitors and simulates them in the virtual world. NTT has incorporated Digital Twin Computing (DTC) into the IOWN concept and is developing and using its 4D digital platform™ as a supporting technology. The platform includes real-time integration of sensing data with high-precision location and time information in the Advanced Geospatial Information Database, which contains rich semantic information and enables high-speed analysis and prediction.

Traffic rectification is drawing attention as an application area of the 4D digital platform™. To apply the platform to traffic rectification, it is essential to evaluate and predict the effects of individual user's behaviors on traffic as a whole under transportation-demand management. NTT Group companies and the Hanshin Expressway Company are jointly studying the effectiveness of urban road-traffic rectification. For example, they are conducting traffic simulations that connect a variety of times-series spatial data and providing traffic recommendation information to users on their smartphones. Also being planned is a demonstration of integrated data analysis and usage that includes training for increasing the value of recommendations on the basis of the results of behaviors carried out by users in response to recommendations (**Fig. 7**).

Improving technologies for linking, integrating, and using diverse time-series and spatial data promises to benefit not traffic rectification but also fields such as mobility and marketing.

(2) Trust technology × Multilingual technology

The use of generative AI in speech synthesis is bringing advancements to technologies such as text-to-speech, which reads written text aloud in a natural tone, and technologies that sample the voices of real people for use in speech synthesis. However, the practice of training the voices of characters for generative AI without the permission of actors or copyright holders and producing different contents with the trained data is problematic. This has led the Japan Actors Union, which includes voice actors and actresses, to launch a public awareness campaign with a video calling for the necessity of creating rules for the use of human voices for AI. Besides promoting the fair use of training data, a system that provides fair revenue sharing is also being sought.

Combining NTT's multilingual technology and trust technology provides a solution to these problems. First, NTT's multilingual speech-synthesis

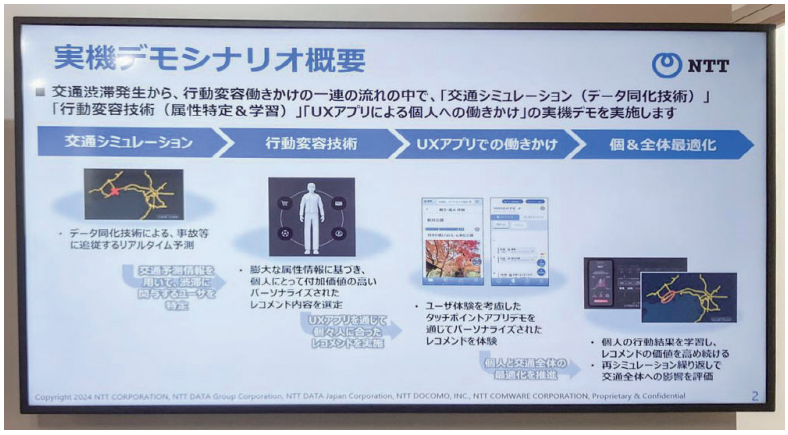

Fig. 7. Overview of the traffic rectification demonstration.

Fig. 8. Demonstration of multilingual speech-synthesis AI technology.

technology enables a tailor-made speech-synthesis model to be constructed by learning the base speech-synthesis model together with the speaker's voice in a session ranging from as short as a few minutes to at most about 10 minutes. The technology can use this model to achieve cross-lingual speech synthesis in Japanese, English, Chinese, and Korean. NTT's trust technology applies blockchain technology's transparency and tamper-proofing functions, which are also used in cryptocurrencies, to tags attached to voice data, speech models, and speech synthesis so that the authenticity of each piece of data can be verified. This technology also facilities revenue sharing by providing histories of data usage.

At this exhibit, visitors experienced a demonstration at which the generative AI learned the voice of a real-life celebrity or announcer and answered questions with a voice similar to theirs. The technology also provided responses in multiple languages (**Fig. 8**).

NTT seeks to create opportunities to use voice content globally by connecting partners who wish to provide their own voice as intellectual property with parties who wish to use AI speech in services and goods.

5. Conclusion

NTT R&D Forum 2024 themed “Integral” showcased a solid path toward the technology integration and practical application of IOWN in the research, development, and business areas. Efforts to innovate business using generative AI and efforts to reduce power consumption to support the continued use of generative AI into the future are noteworthy. The evolution of tsuzumi and advancement of PEC technology provided a concrete solution to a societal challenge of simultaneously achieving the advancement of AI and sustainability. As represented by the creation of the space business brand NTT C89, NTT’s endeavor to a new field illustrates its ambitious goal of expanding the possibilities of IOWN from the ground to space. The Forum presented NTT’s commitment to technology development from basic research to social implementation for the sustainable development of a digital society.

Members of NTT R&D Forum Secretariat: (from left) Shunsuke Mori, Hironari Yokoi, Atsushi Kobayashi, Yuichi Maki, Takanori Watanabe.