

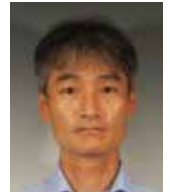
# Results of the 3<sup>rd</sup> Germany-Japan Beyond 5G/6G Research Workshop

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## 1. Introduction

The National Institute of Information and Communications Technology (NICT) is engaged in international exchange on Beyond 5G/6G research. NICT co-hosted the 3rd Germany-Japan Beyond 5G/6G Research Workshop with 6G Platform Germany, an organization that organizes 6G research projects in Germany.

Dates: February 5 (Mon) to 6 (Tue), 2024

Venue: NICT Innovation Center (15th floor, Nihombashi Tower, Tokyo)

Participants: Open to anyone interested in Beyond 5G/6G research activities

The first day was the day after “Risshun” (the first day of spring), but the weather was unexpected, with snow starting to fall in the afternoon to a few centimeters in Tokyo. Nonetheless, 75 participants (52 from Japan and 23 from Germany) participated and engaged in an enthusiastic exchange of opinions.

## 2. Review of previous events

This workshop started as a research-level international exchange activity following the exchange of opinions

between Japan’s Ministry of Internal Affairs and Communications (MIC) and the German Federal Ministry of Education and Research (BMBF). The two countries are working to build cooperative relationships between universities, research institutes, and the private sector through Beyond 5G/6G R&D collaborations. Mr. Takeaki Matsumoto, Minister for Internal Affairs and Communications, and Ms. Bettina Stark-Watzinger, Federal Minister of Education and Research, signed a Memorandum of Cooperation in the field of communications technology on May 11, 2023.

The 1<sup>st</sup> Germany-Japan Beyond 5G/6G Research Workshop was held from April 24 to 25, 2023 at the NICT Headquarters in Koganei. The workshop was attended by 73 participants (51 from Japan and 22 from Germany). From Japan, participants included researchers from NICT and Beyond 5G R&D Fund commissioned research institutions, members of the Beyond 5G Promotion Consortium, representatives of telecommunications carriers, vendors, and academic societies. From Germany, participants included representatives

from the BMBF 6G Research Hubs of 6G (6GEM, 6G-Life, 6G-RIC, and Open6GHub), 6G Platform Germany, universities, and private companies.

The first workshop included presentations of research activities on Beyond 5G/6G in both countries, a poster session, and a panel discussion to explore the possibilities and directions of cooperation between Japan and Germany. In a questionnaire survey conducted after the event, positive comments were received such as “the event was very helpful in giving an idea of the concrete initiatives of Japan and Germany for Beyond 5G/6G” and “it provided ample time to discuss with participants from Japan and Germany.”

The 2<sup>nd</sup> Germany-Japan Beyond 5G/6G Research Workshop was held in Berlin at the same time as the Berlin 6G Conference from June 27 to 29, 2023. The Berlin 6G Conference is an exchange event that brings together people engaged in 6G from all over Germany. Despite being held for the first time, the event was attended by more than 1,000 people. From Japan, 12 representatives from the Beyond 5G R&D Fund commissioned research institutions, NICT, Beyond 5G Consortium, and the Japanese Embassy in

■ Figure 1: Group photo of participants



Germany participated.

In the plenary session on the first day, Japanese participants took the stage and took commemorative photos with officials from the German Federal Ministry of Education and Research and 6G Platform Germany. In addition, Dr. Iwao Hosako, Director General of the Beyond 5G R&D Promotion Unit at NICT, Mr. Yoji Kishi, Executive Director of KDDI Research Inc., and Mr. Takehiro Nakamura, Director at NTT DoCoMo, who represented the Beyond 5G Consortium, each gave a lecture.

The Germany-Japan Beyond 5G/6G Research Workshop was held as one of the parallel sessions of the Berlin 6G Conference and was attended by more than 60 participants. There were 13 proposals from both countries on research themes for cooperation between Japan and Germany that were accepted beforehand. A representative from the Federal Ministry of Education and Research of Germany announced that it would provide budget support for around one year starting from the following year for Germany-Japan R&D collaborative projects. Also, a tour of the Berlin 6G Conference demonstration

exhibit showcased the various use cases of 6G.

### 3. Initiatives of the German and Japanese governments

Lectures were delivered on the initiatives of the German and Japanese governments on Beyond 5G/6G. It became a valuable opportunity to grasp the policy trends of the MIC and the BMBF.

Mr. Takahiro Tanaka (Deputy Director, MIC) gave a lecture on Japan's Beyond 5G/6G promotion strategy. In addition to the R&D and testbed maintenance that have been carried out since FY2021, he explained about the launch of the 81.2-billion-yen R&D fund in FY2023. He also mentioned that a new Beyond 5G/6G strategy will be announced this summer.

Mr. Kai Börner (VDI/VDE Innovation + Technik) introduced Startup Connect, a BMBF initiative to support start-ups in the field of telecommunications. Four incubators were set up to provide start-ups with information, measurement equipment, and networking contacts. Start-ups also receive funding to accelerate the transfer

of research results into the market. He also mentioned that BMBF and MIC are discussing ways to implement Germany-Japan cooperation projects. The first phase of the Germany-Japan cooperation project will be presented at the 4th Germany-Japan research workshop to be held in Berlin in July 2024.

■ **Figure 4: Lecture by Mr. Takahiro Tanaka**



■ **Figure 5: Lecture by Mr. Kai Börner**



■ **Figure 2: Photo from the first workshop**



■ **Figure 3: Photo from the second workshop**



### 4. Panel Discussion

The two-day panel discussions delved on the possibilities of Germany-Japan cooperation in research and development on Beyond 5G/6G. The panelists and the audience engaged in lively discussions.

#### 1. Overview of the first day

The panelists on the first day were Prof. Akihiro Nakao (University of Tokyo), Prof. Kei Sakaguchi (Tokyo Tech), Dr. Takayuki Kuroda (NEC), Mr. Takehiro Nakamura (NTT DoCoMo), Prof. Aydin Sezgin (Ruhr University Bochum), Dr. Renato Cavalcante (Fraunhofer HHI), and Dr. Szabolcs Malomsoky (Ericsson). Dr. Kentaro Ishizu (NICT) served as the moderator.

In the discussions, the question of the importance of using digital twins in the Beyond 5G/6G era not only for

■ **Figure 6: Panel discussion on the first day**



■ **Figure 7: Panel discussion on the second day**



monitoring but also for services that involve interaction with people was raised. A participant expressed the view that digital twins will undergo gradual advancement, wherein today's digital twins are still in the 0th stage of monitoring and sensing. This will be followed by the first stage of visualization, the second stage of optimization, and the third stage of prediction. He also mentioned that digital twins could be used to predict lightning strikes, traffic congestion, and people's health conditions. Initiatives of telecom operators in using digital twins to autonomously manage their networks and increase their resilience were also introduced, and the use of digital twins outside of the telecom industry was also suggested.

Next, concerns were raised about the sustainability of artificial intelligence (AI) and digital twins as they consume large amounts of energy. Efforts to develop lightweight AI with emphasis on Japanese language processing in Japan were then introduced. In addition, the necessity to control the network and reduce power consumption in accordance with the communication demand was pointed out. The importance of sustainability as well as the pursuit of performance in the system design of Beyond 5G/6G was also noted.

As AI and machine learning (ML) have become increasingly used in research, researchers discussed whether they should focus more on mathematical analysis or AI/ML data. Some were of the opinion that since Beyond 5G/6G is AI-native, young researchers should actively use AI/

ML while keeping in mind the ethical issues of their use.

Lastly, discussions were held on potential topics for cooperation between Germany and Japan, concluding that resilience, digital twins, energy consumption, and AI will continue to be considered as candidates.

## 2. Overview of the second day

The panelists on the second day were Mr. Hideaki Takahashi (Nokia), Dr. Satoshi Konishi (KDDI Research Inc.), Dr. Takeshi Matsumura (NICT), Mr. Yuji Tazaki (Fujitsu), Prof. Andreas Stöhr (Univ. Duisburg-Essen), and Mr. Niels König (Fraunhofer IPT). Prof. Haris Gačanin (RWTH Aachen Univ.) served as the moderator.

First, measures to curb energy consumption were discussed. Among the measures cited were the use of optical fibers and the transition from centralized processing to distributed processing. The ability of NICT's wireless emulator, which enables demonstration of a large-scale wireless system in a virtual space, to make system construction efficient was mentioned.

Next, the fusion of radio and light was discussed. The difficulty of installing optical fibers in different sorts of areas in Japan was pointed out, along with the necessity to strengthen the entire network, rather than choosing between wireless or optical, in light of the doubling of traffic every three years. It was also mentioned that customers view networks from an end-to-end perspective.

With the advent of the new generations

of 4G, 5G, and Beyond 5G/6G, it was noted that the management of heterogeneous networks will become crucial. Efforts to develop a standard that allows flexible frequency selection at 3GPP were introduced. Also, the effectiveness of evaluating the response using AI to avoid network failures was suggested since the optimal solution differs from generation to generation.

Regarding topics for Germany-Japan cooperation, the panelists have agreed that research institutes, vendors, and operators should continue considering issues of common interest.

## 5. Lectures by researchers

The rich variety of presentations from researchers showed that Beyond 5G/6G can serve as the foundation of all industries and social activities.

Dr. Tetsuya Ido (NICT) introduced the Wi-Wi space-time synchronization technology. For satellites, a technology has been established to compare time between UTC (Coordinated Universal Time) and JST (Japan Standard Time) with an accuracy in nano ( $10^{-9}$ ) seconds. Wi-Wi makes this possible between small wireless devices. They are also developing an antenna that reduces the phase error arising from the transmission and reception angles.

Dr. Motoaki Hara (NICT) presented the development roadmap for an ultra-compact atomic clock with a size of 0.5 cc or less and the latest development progress. He also introduced the cluster clock infrastructure, in which numerous communication nodes equipped with



atomic clocks cooperate to achieve highly stable and reliable time synchronization, and introduced the new time-series algorithm required for this technology.

Dr. Ryosuke Isogai (NICT) reported the success of a demonstration experiment for transmitting 120 MB of data in about 0.5 seconds, the time it takes for drones to pass each other. Two drones were equipped with IEEE802.15.3e-compliant 60-GHz wireless devices, and high-frequency communication was established within the short period of time that the two drones passed each other, enabling high-capacity data transmission.

Mr. Kentaro Tani (NGK Insulators) introduced a hybrid bonded wafer for sub-terahertz band antenna. The wafer, which is made of a silica glass functional layer and a silicon base substrate directly bonded together, has low loss characteristics over a wide frequency band of 100 GHz or more, and is resistant to high temperatures and high humidity.

Dr. Yusuke Dohi (JR East) introduced the efforts of the Research and Development Center of JR East toward the utilization of Local 5G and discussed the necessity of technical and institutional studies to construct linear wireless areas such as for railway tracks. The paper by Dr. Dohi reporting on Local 5G verification test on Shinkansen Deadhead Line won the 39<sup>th</sup> Telecom System Technology Award of the Telecommunications Advancement Foundation.

Mr. Niels König (Fraunhofer IPT) introduced production research conducted

at the 5G-Industry Campus Europe. This research is aimed at concurrently solving problems of quality, time, and cost with the use of 5G. They demonstrated that a 5G multi-sensor platform enabled a 5-axis milling machine to accurately create aircraft engine blades by transmitting data such as acceleration, strain, temperature, and humidity.

Mr. Till Witt (NXP Semiconductors) introduced German initiatives in quantum computing. The German government included 2 billion euros for R&D on quantum technologies and quantum computing in the budgetary package for economic stimulus in 2020. NXP semiconductors is involved in three governmental projects; namely, demonstration of a 10-Qbit computer, development of a 50-Qbit prototype computer, and construction of a modular platform.

### 6. Poster session

Japanese and German researchers engaged in active discussions with participants in front of the posters. The following poster presentation overview excludes posters related to research presented in the lectures and demonstrations.

Dr. Tobias Meuser (TU Darmstadt) presented their experiments with functions for switching the components of the wireless access network and switching the various nodes of the core network by ML in order to increase the resiliency of 5G and 6G networks.

Mr. Michael Weimer (Fraunhofer FHR) presented their research on joint communication and sensing (JCS), which uses radio waves for wireless communication in combination with sensing. They presented initial results towards formulating the concept for a long-range OFDM radar for demonstration of JCS and its required technologies.

Mr. Andreas Bathelt (Fraunhofer FHR) presented his research on time synchronization for JCS. He discussed a basic algorithm that creates a virtual, common clock using a consensus approach among multiple devices and then adjusts the different local times of these devices. He also presented an asynchronous operation of this algorithm.

Dr. Sören Kerner (Fraunhofer IML) presented their research on the PACE Lab, a robotics 3D-data acquisition test field featuring a high-precision motion capturing system as well as software-defined radio system to develop 6G-driven services in the context of the 6GEM project. Within the PACE Lab, the simulation-based digital twin reproduces the experiment implemented in physical space in real time, including shadowing effects by obstacles.

Mr. Niels König (Fraunhofer IPT) presented their collaborative research with an interdisciplinary consortium on manufacturing, cybersecurity, mobile technology, and academia to analyze security risks posed by 5G and to develop measures for prevention, detection, and response at the 5G-Industry Campus

■ **Figure 8: Lecture from the Japanese side (Dr. Tetsuya Ido)**



■ **Figure 9: Lecture from the German side (Mr. Till Witt)**



Europe. Furthermore, he also presented a testbed activity investigating mmW in industrial applications, especially the bandwidth implications on propagation, performance, and use cases.

Dr. Renato Cavalcante (Fraunhofer HHI) introduced the activities of the 6G Research and Innovation Center (6G-RIC). The highlights of their activities include verification experiments on the world's first long-range D-band system and channel charting for indoor localization.

Dr. Dirk Wübben (University of Bremen) and Mr. Till Witt (NXP Semiconductors) presented their research on the integration of terrestrial and non-terrestrial networks. They are investigating technical aspects such as functional split and RAN placement among satellites, HAPS, drones, and terrestrial systems and information-preserving compression for efficient and reliable transmission.

Prof. Haris Gačanin (RWTH Aachen University) presented their research on the applications of machine learning in wireless communication. They developed a prototype system to improve energy efficiency by efficient utilization of FPGA based on operational data and learning functions.

Prof. Andreas Stöhr (University Duisburg-Essen) presented their demonstrations on wireless communication in THz band such as multi-beams serving two users and high data rates of 200 Gbit/s.

Dr. Nidal Zarifeh (University Duisburg-Essen) presented their research on reliable THz connection in a smart hospital. They are modelling THz channels in a surgery room scenario and conducting related measurements and experiments to establish connection between the THz access point and VR headset.

Dr. Yuki Yoshida (NICT) presented their research on data sharing between the Germany-Japan optical network testbeds in a way that is compliant with utilization policies that uphold data sovereignty, i.e., policies that are defined by the data owner, in order to accelerate research on network

AI.

Dr. Kentaro Furusawa (NICT) introduced a method for generating high-quality terahertz reference signals from lasers used for frequency standards using compact, power-saving device called microcomb, and reported on their efforts to fabricate and evaluate devices.

Prof. Sangyeop Lee (Tokyo Tech) reported that they have fabricated and evaluated film-type absorber, reflector, and radome with characteristics of millimeter- and terahertz-wave bands and obtained favorable results.

Dr. Takahiro Kaji (NICT) presented their research on radio-over-fiber (ROF), which transmits terahertz frequency signals using optical fibers. They have fabricated a D-band (110-170 GHz band) modulator with antennas and demonstrated high-speed direct conversion between terahertz waves and light.

Mr. Yoichi Kansaku (JR East) presented their research on an integrated service that covers international tourism experience to satisfy the end-to-end needs of inbound tourists in Japan. The service supports tourists in online planning from their country of departure and in guiding them to their destinations after arrival.

■ **Figure 10: Poster session**



## 7. Demonstration session

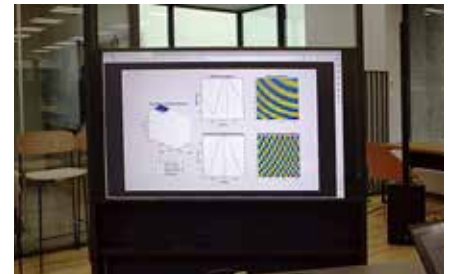
Two demonstrations were presented by researchers from Germany. Both were demonstrations that allowed participants to experience the service and attracted wide attention among the participants.

Prof. Aydin Sezgin (Ruhr University Bochum) presented their research on reconfigurable intelligent surfaces (RIS). They showed a demonstration video in

which an RIS-equipped drone was used for angle-of-arrival estimation.

Prof. Christian Zenger (Ruhr University Bochum) presented a demonstration video on remote monitoring in security areas through the detection of radio frequency signals using PHYSEC's anti-tamper radios. In case of physical intrusion and destruction, the changes detected in radio frequency signals trigger a warning.

■ **Figure 11: Demonstration by Prof. Aydin Sezgin**



■ **Figure 12: Demonstration by Prof. Christian Zenger**



## 8. Conclusion

Lively discussions took place among the participants in all the sessions, reflecting the commitment of Japanese and German researchers towards the advancement of Beyond 5G/6G. It seemed that research on the Japanese side focused on important technological seeds, while that on the German side focused on services that are easy to visualize. The keen interest among the German researchers in reducing energy consumption was remarkable.

The 4<sup>th</sup> German-Japan Beyond 5G/6G Research Workshop will be held from July 1 to 4, 2024 in Berlin. It will be open to anyone interested in Beyond 5G/6G research activities, so we hope that many people will be able to attend.