Open Up Bright Future

2024
Summer

Xross B5G

English Edition

Beyond 5G R&D Promotion Unit
National Institute of Information and Communications Technology

Orchestrator opens doors to the future

NICT
Beyond 5G R&D Promotion Unit

Contents

Xross B5G 2024 Summer

Feature

Orchestrator opens doors to the future

Update

Towards Realization of Terahertz Band Mobile Wireless Communication Services in Beyond 5G

- The Cutting Edge of R&D on Terahertz Band Wireless Fundamental Technology -

1. Introduction

"Beyond 5G Promotion Strategy" formulated by the Ministry of Internal Affairs and Communications in June 2020 listed issues such as ultra fast & large capacity wireless communication and ultra low latency as areas in which R&D should be focused. To meet the demand for realizing higher speed and larger capacity wireless communication, the frequency used in wireless communication is gradually becoming higher. **"Terahertz wireless communication"** is a wireless communication technology that uses frequencies in the range of 100GHz to 10THz. 100GHz to 300GHz is expected to be used in Beyond 5G. Furthermore, terahertz wireless communication, which enables ultra fast & large capacity wireless communication, is also attracting attention as a mobile communication technology. Here, we introduce our R&D initiatives on Terahertz band wireless communication fundamental technology with the aim of utilizing Terahertz ultra fast & large capacity wireless communication capabilities as a mobile service.

2. Terahertz band "ultra narrow spot wireless service"

It is assumed that the frequency band below 100GHz will be used for the fifth-generation mobile communication system (5G) currently in service, and the 28GHz band (27.0 to 29.5GHz) has been allocated as the highest frequency band in Japan. On the other hand, if the radio wave used for wireless communication is assumed to be around 300GHz of the terahertz band, for example, the frequency will be 10 times or more and the wavelength will be 1/10 or less, which will make it possible to reduce the size of devices and antennas extremely small. Furthermore, as the transmission capacity, about 10Gbps is assumed using a bandwidth of 400MHz in 5G, but in the wireless communication of the terahertz band using the 300GHz band, a large capacity communication exceeding 100Gbps is also assumed. As described above, in the wireless communication of the terahertz band, it is expected that the antenna can be miniaturized to a small size, and the communication speed can be increased.

On the other hand, there are technical subjects associated with higher frequencies. In general, the higher the frequency, the closer the transmission of radio waves is to the properties of light, and the greater the attenuation by the atmosphere. Therefore, in wireless communication in the terahertz band, it

is more advantageous to narrow down the beam for communication. However, if it is to be applied to mobile communication, it is necessary to have a technique for accurately directing a narrow beam to a communication counterpart while moving. Conversely, even if it is assumed that communication is performed only when the beams are aligned with each other without accurately directing the beams, the communication speed of wireless communication in the terahertz band is sufficiently higher than that of conventional 5G in the first place, and there is a possibility that it will be sufficiently practical depending on the application. We call this type of mobile communication **"ultra narrow spot wireless service"**.

The following is a detailed explanation using figures. Figure 1 shows the relationship between communication capacity and communication area. The case of conventional mobile communication up to 5G (microcell) is shown in orange color, and the case of ultra narrow spot wireless service is shown in blue.

Although the communication speed of conventional microcell is low, the communication area is wide, and communication is performed for the entire communication time within the area. On the other hand, the communication speed of ultra narrow spot wireless service is extremely high although the communication area and time are limited. Here, if there is a case in which the capacity that can be communicated in the blue ultra narrow spot is larger than the capacity that can be communicated in the orange-colored microcell, it may be sufficiently practical depending on the use case.

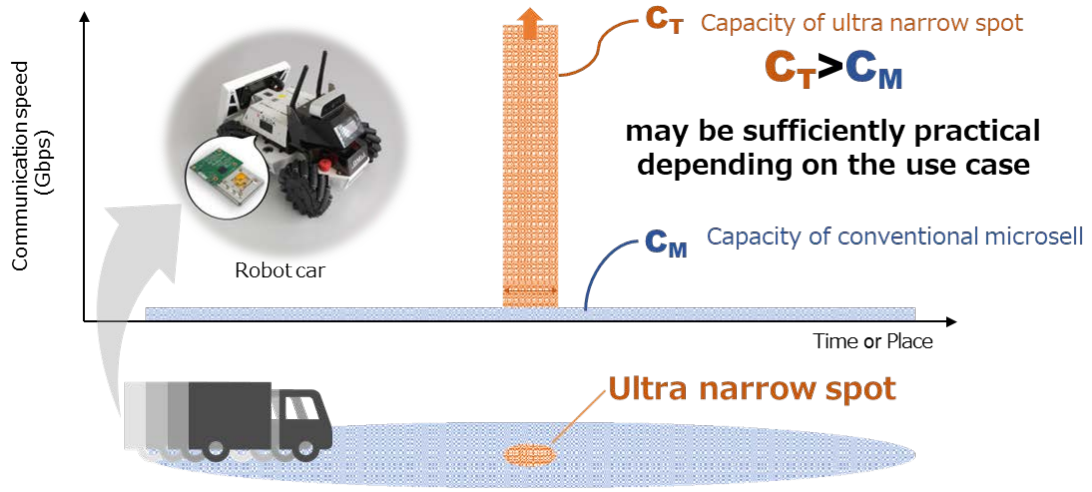


Fig. 1 Difference between Conventional Microcell and Ultra

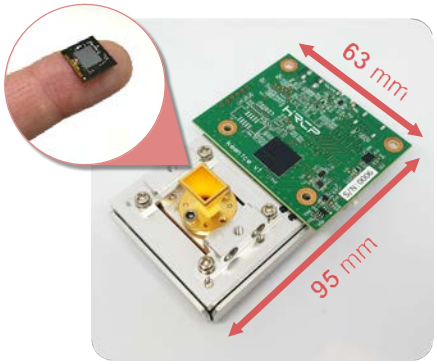
3. Ultra narrow spot wireless service demonstration system

The Institute of Electrical and Electronics Engineers (IEEE) has established a communication standard called **"IEEE802.15.3d-2017 (3d)"** for high data rate wireless multi-media networks using terahertz band radio waves, which is mainly based on the use of frequencies in the 300GHz band. However, actual equipment using terahertz band in accordance with this standard is still under development, and there are almost no operational examples. For this reason, we have built a demonstration system using a communication system compliant with the **"IEEE802.15.3e-2016 (3e)"** communication standard, which is already in practical use as a high data rate wireless multi-media networks standard using millimeter-wave in the 60GHz band, and are verifying use cases for ultra narrow spot wireless service and building an evaluation environment.

Figure 2 shows how the demonstration system of the ultra narrow spot wireless service works. The robot car assumed to be a mobile station is equipped with a camera for recording and a millimeter-wave wireless communication module (Fig. 3) compliant with the **"3e"** standard. When the robot car is started, the camera records a moving image for a few seconds. After the recording is completed, the robot car moves toward the ultra narrow spot zone where it can communicate with the base station. When the robot car reaches the ultra narrow spot zone, the communication link is established in substantially less than 1 millisecond, the recorded data is instantaneously transmitted to the base station side, and the received recorded data is play backed on the display.

Fig. 2　Ultra Narrow Spot Wireless Service Demonstration System

4. Concluding remarks



Parameter	Value
Carrier frequency	60.48 GHz or 62.64 GHz
Bandwidth	2.16 GHz
Data rate	∽ 6 Gbps
Transmission distance	A few ∽ hundreds of centimeters
Connection establishment	< 2 ms
Compatible standard	IEEE 802.15.3e, TransferJet X
RF I/F	WG-15 UG-385/U
Baseband I/F	USB, 10 Gigabit Ethernet
Local storage	> 200 GB (UFS)

Fig. 3　IEEE802.15.3e Compliant Millimeter Wave Wireless Communication Module and Main Specifications

(from HRCP Research and Development Partnership)

"3e", which has already been put into practical use as a high data rate wireless multi-media networks standard, is assumed to be a millimeter-wave standard in the 60GHz band. However, if the frequency of

the carrier wave is converted to 5 times, it becomes a radio wave in the 300GHz terahertz band. In this case, a system based on the **"3d"** standard assuming the terahertz band can be constructed (Fig. 4). In other words, it is possible to assume a migration path to the terahertz band where a communication system in which the frequency of **"3e"** is converted to the 300GHz band will be put into practical use and spread first. It can be said that the verification in the **"3e"** system such as the demonstration system this time has the potential to be the closest critical path to the practical application of terahertz wave wireless communication.

Examples of non real time, ultra fast & large capacity data services suitable for the use of ultra narrow spot in the terahertz band include high definition environmental measurement/observation/data collection, high definition ultra large capacity map distribution/cyber space data distribution for autonomous car. In addition, data centers, fronthaul / backhaul lines, small cell access, and device-to-device communications are also envisioned as examples of ultra fast & large capacity, ultra low latency real time communications services suitable for the use of terahertz. With these service examples in mind, we plan to continue R&D toward the practical application of terahertz band mobile wireless communications in Beyond 5G, including the construction of verification environments for terahertz systems compliant with the **"3d"** standard, protocol verification, and examination of cyber space utilization services using distributed collection of high precision space-time stamped large capacity sensing data.

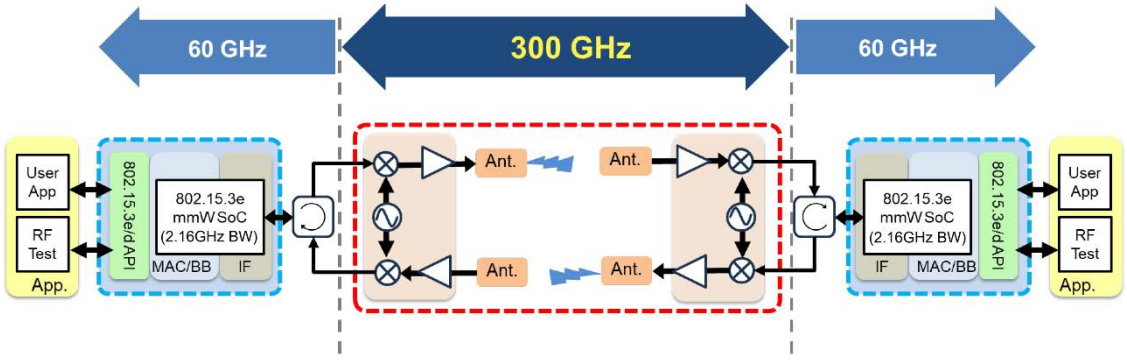


Fig.4 Example of a communication system in which the "3e" system (60 GHz band) is frequency-converted to the 300GHz band

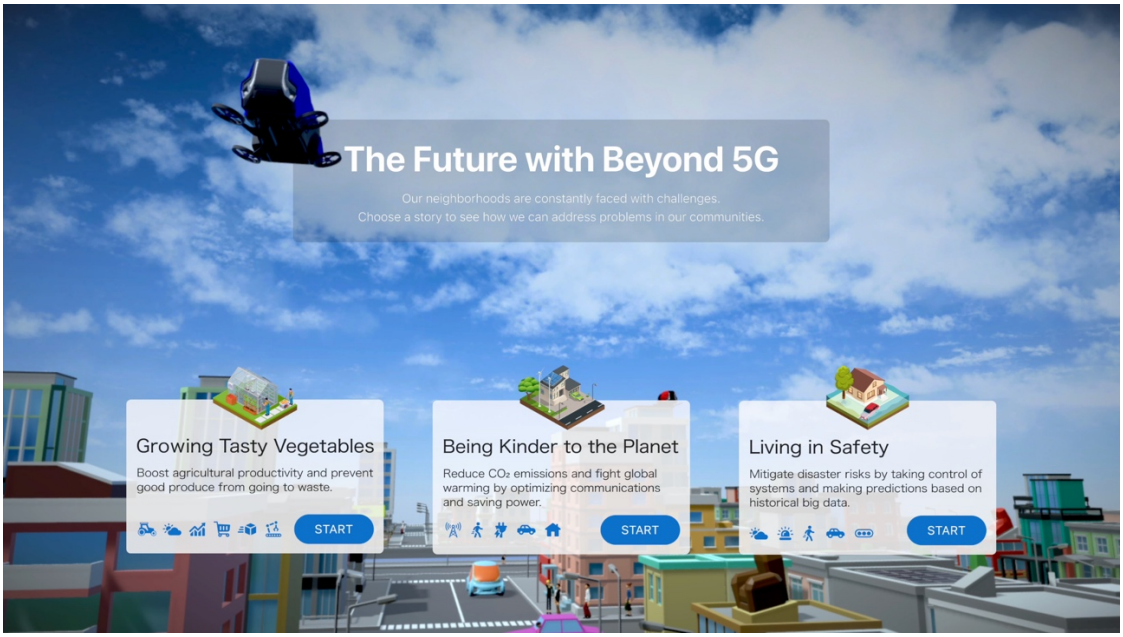
Update

Tools for Experiencing Orchestration to Connect Industries and Solve Social Issues

- You Solve Social Issues in Digital Twins Collaboration -

1. Introduction

To realize Beyond 5G, NICT is conducting R&D on leading-edge elemental technologies and Beyond 5G architecture as a mechanism for utilization across industrial boundaries. Through this architecture, Beyond 5G is expected to become a place for the creation of new services Beyond its mere function of providing communications. This article introduces a tool that allows users to experience the process of solving social issues by using **"orchestrator,"** a function for determining and making a collaboration of an appropriate combination of systems across industrial fields in the Beyond 5G architecture.



2. Overview of Experience Tool

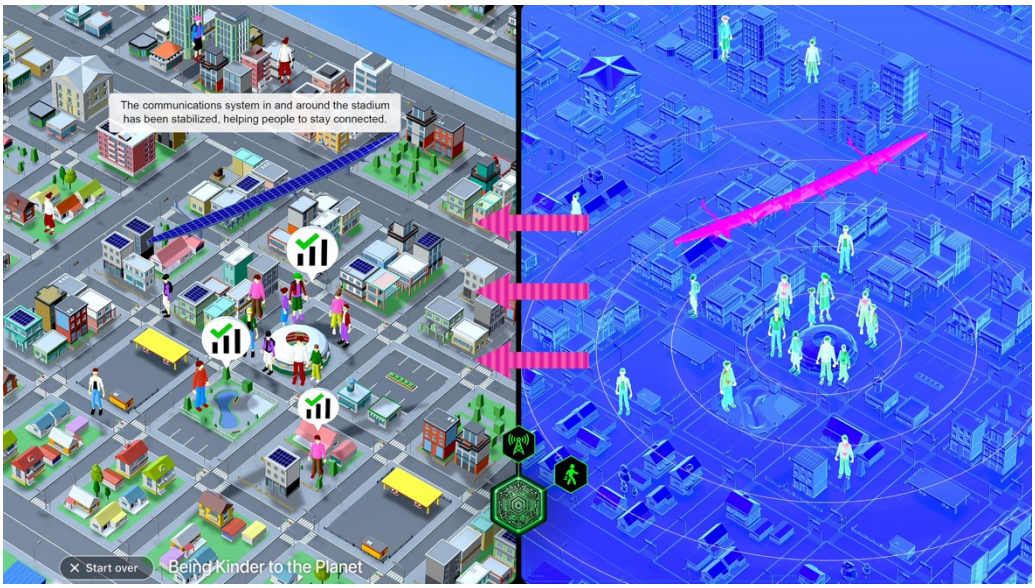
With this tool, you can experience how an **"orchestrator"** can determine the appropriate combination of systems across industrial fields and collaboration them to solve problems and provide new services immediately. Concretely, in accordance with three scenarios with the themes of **"reducing high-productivity agriculture and food loss," "saving energy and reducing greenhouse gases," and "avoiding disaster risk,"** you can experience how orchestrator appropriately collaborate digital twins provided by each business operator, enabling users to use necessary services in a timely manner, and solving various problems

while watching and operating physical space and cyberspace.

■ Scenario 1: I want to deliver delicious vegetables

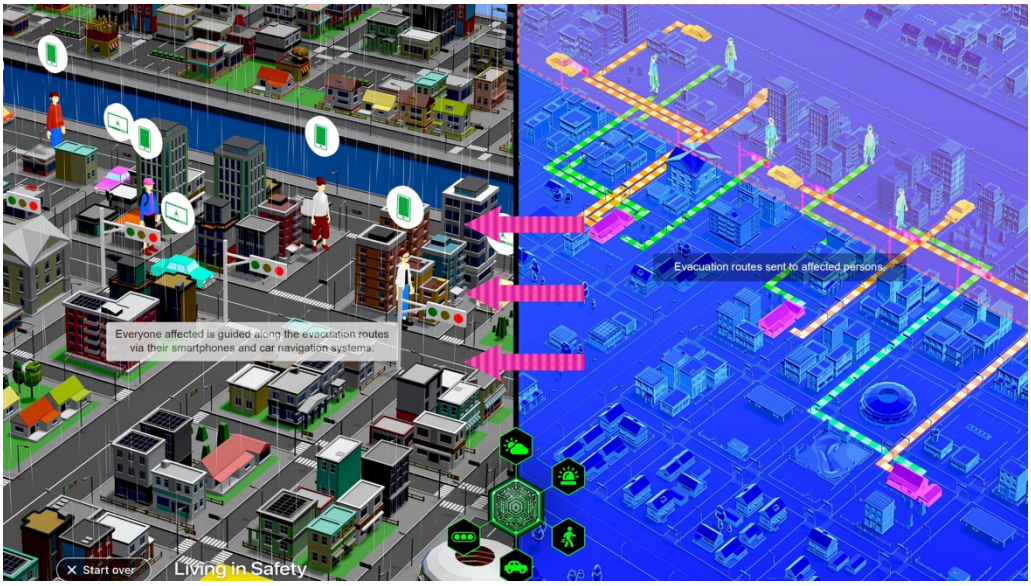
Based on the primary industry, where labor shortages are currently progressing due to the declining birthrate and aging population, it describes the future in which technology has advanced and digitization and automation of agriculture have been realized. In the agricultural digital twin, production management is conducted, and growth is managed appropriately, but the optimal planting plan cannot be determined by the agricultural digital twin alone. Therefore, **"orchestrator"** proposes the most productive planting plan in consideration of future sales prices and harvesting time by collaboration the agricultural digital twin with future weather data and supply chains such as markets, distribution, and retail. It also contributes to the reduction of food loss through collaboration with food processing plants and the diversion of substandard products to processing plants.

■ Scenario 2: I want to be more environmentally friendly



As for the future, it describes a future in which the quality of life has improved in all aspects, such as the electrification of cars and buses in the city, the ultra fast & large capacity of wireless communication infrastructure, and the expansion of communication areas vertically. Based on the digital twin information of people flow and traffic flow, orchestrator proposes an optimal communication area that minimizes power consumption while maintaining communication quality. In addition, to maximize the use of energy such as solar power generation, which does not generate greenhouse gases, collaboration will be made with batteries mounted on EVs and electric buses and electric water heaters to adjust the overall supply and demand balance. By doing so, we will realize further energy conservation and greenhouse gas reduction without compromising the quality of our lives.

■ Scenario 3: I want to live safely



It describes a future in which damage is minimized by responding quickly and appropriately to unpredictable natural disasters. **"Orchestrator"** constantly identifies people who may be affected by disasters based on digital twin information on people flow and traffic flow and provides individual appropriate evacuation routes to people at elevated risk of disaster based on flood forecasts by meteorological digital twin. In addition, it provides collaboration with traffic systems that control traffic signals and restricts access to dangerous areas throughout the city. These measures will reduce the risk of damage and realize a safer life that prioritizes human life.

3. Notes from Experience Tool Development Staff

The virtual reality tools and videos on Beyond 5G architecture, which are the exhibits we have produced so far, were suitable for understanding the general framework of Beyond 5G, but it was difficult to understand what specific problems could be solved by what combination of systems. In the production of this tool, we have been examining scenarios so that people in various industries will be interested in it by showing this point.

However, it took quite a long time to actually start the study. Even now, there are many examples in which services are appropriately provided by combining information manually, and some of them lack novelty. For example, increase the number of trains and buses by predicting the people flow. For example, it was difficult to express medical care on a map, and the fishery scenario was like the agriculture scenario. There were some things that were out of consideration, so it was exceedingly difficult to select a scenario.

Through this tool, we hope that you will experience and understand the mechanism of collaboration and the flow of problem solving across industrial boundaries, which will trigger discussions and participation in Beyond 5G R&D. We are planning to exhibit this tool at exhibitions and other events in the future, and we would like you to experience it and give us your opinions.

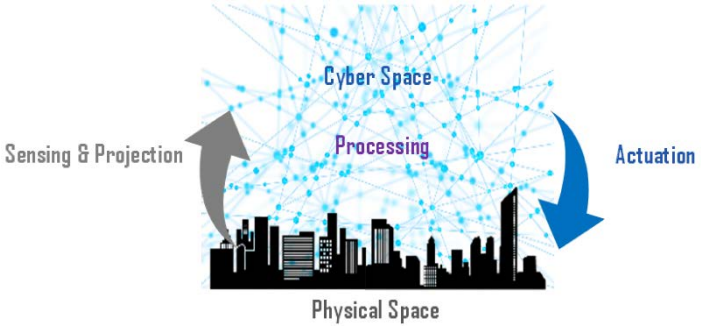
(This experience tool is displayed in the exhibition room [*1] of NICT Headquarters (Koganei City, Tokyo). Please experience it. You can also see the video of this experience tool on the URL of the QR code [*2] below.)

*1 https://www.nict.go.jp/en/index.html

*2 https://beyond5g.nict.go.jp/media/tpmov.html

(Appendix) Roles of orchestrator

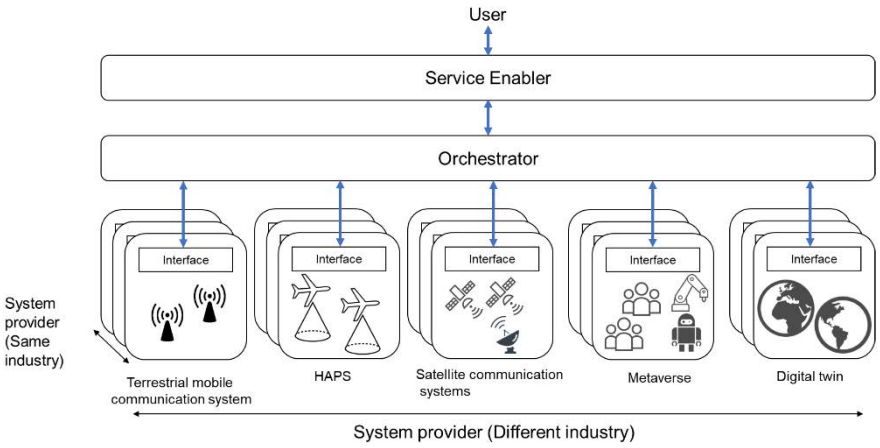
"Orchestrator" refers to software and systems for automating and making autonomous the setup, management, and operation of complex and large-scale information and communications systems. It is common at present for each business operator to operate independently in order to efficiently use their own network and computer resources. On the other hand, the **"Beyond 5G/6G White Paper"** proposed by the NICT interprets the roles of **"orchestrator"** more broadly and gives it new roles as a trump card for Beyond 5G to be used as infrastructure to solve social issues.



In the Beyond 5G era, it is thought that CPSs (Cyber Physical Systems) will be used in a variety of social activities. For example, physical space will be measured and projected through an information and communications network, and the results will be aggregated into digital twins in the cyberspace. In addition, the digital twins will be analyzed, and based on the results, various actuators will be used to drive the real

world. If CPS is used, resources such as communication equipment, frequency, space, and time can be handled more dynamically than before, and it is expected that it will be possible not only to upgrade and improve the efficiency of individual systems through new technologies, but also to optimize society across industries.

At the initial stage when a CPS is actually used in a service, it is assumed that each business operator builds a CPS based on its own resources and starts a service within the scope of the CPS. On the other hand, when considering a mechanism such as generative AI in which a user inputs a desired service at a prompt and automatically constructs the service as a series of supply chains, if it is possible to bring together and configure each CPS across the boundaries of different industries and different businesses, it is possible to determine an appropriate combination from among the CPS brought together according to the functions and performance required by the user, and finally configure and provide the service to the user instantly.



In this case, if we manually design the services that users need from the myriad combinations of CPS that will explode in the future, there will naturally be a limit. Therefore, in the discussion of the Beyond 5G architecture proposed by NICT for the Beyond 5G/6G white paper, it is assumed that the **"orchestrator"** automatically selects, connects, and configures the optimum system to realize the service requested by the users.

Through this mechanism, system providers will have the opportunity to participate in a wide range of Beyond 5G services, regardless of the type of industry or the scale of their businesses. At the same time, it is expected that unexpected combinations of systems will lead to the creation of services with new value and the resolution of problems that have not been achieved so far. It is also expected that customers will be provided with high-level services immediately through a supply chain that is customized according to the requirements and circumstances of each customer. It is assumed that the entire industry itself will be transformed by the utilization of **"orchestrator."**

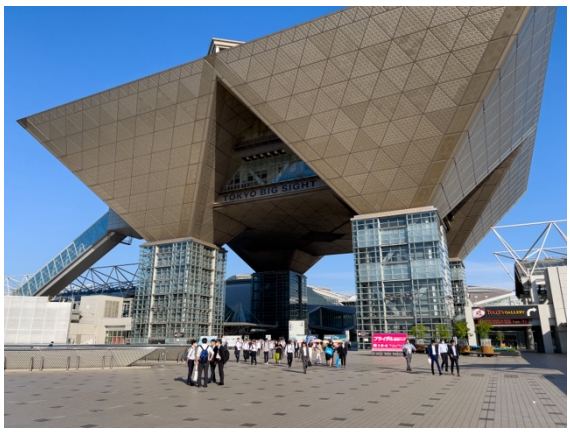
Report

Wireless Technology Park (WTP) 2024 Exhibition Notes

- A New Shape of Society Transcending Industrial Boundaries -

January 12, 2024. While the New Year's mood remains, I received an e-mail from the secretariat of the NICT's WTP Managing Director. Of course, the contents are information about WTP2024 and inquiries about its contents. So, again this year, we started toward the WTP.

"Wireless Technology Park (WTP)" is one of the largest specialized events in Japan focusing on research and development of wireless communication technology. It consists of exhibitions and seminars and attracts more than 20000 visitors every year. The number of visitors in fiscal 2024 was 25,566 (22,691 in 2023), an increase of 13% from the previous year, making it a very lively event.

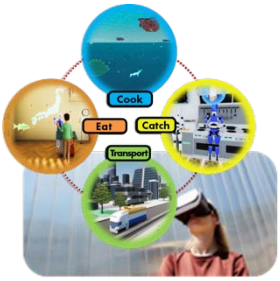


Preparations for the exhibition

This is the third time that Beyond 5G Research and Development Promotion Unit, which was established in 2021, has participated in the exhibition. Let's look back at the history of the exhibition.

■2022

With the first edition of **"NICT Beyond 5G/6G white paper"** published in March 2021, WTP2022 exhibited the outline of the Beyond 5G architecture shown there, three use cases created by NICT researchers, and Beyond 5G elemental technologies to realize it. For the three use cases, we produced and released animated videos (Japanese and English versions) so that more people can visually imagine the future society of Beyond 5G. We also conveyed to many people the utility of collaboration between cross-industry in realizing the future society of Beyond 5G.



Beyond 5G function experience system

■2023

At WTP2023, regarding the Beyond 5G architecture that enables the

bringing together and appropriate combination of CPS functions, we produced and exhibited a new supply chain form as content that utilized **"orchestrator"** functions necessary for the cross-industry digital twins collaboration at each site of primary industry (fishery), processing industry, delivery industry, and consumption, and we had people experience stories about **"orchestrator"** functions in VR with immersive images.

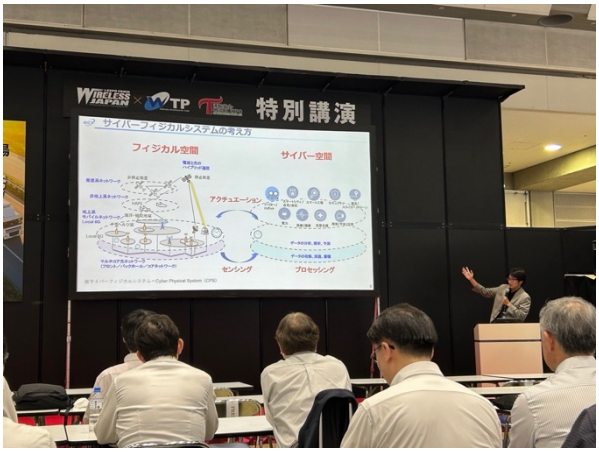
■2024

Now, what is this year's exhibition? Regarding Beyond 5G architecture, detailed examination is being advanced while deepening discussions across each research institute based on Beyond 5G technology being researched and developed at each research institute of NICT. In addition, based on various opinions and ideas obtained through the workshop **"Zero Gravity Event"** connected to cross-industry collaboration, which has been held multiple times, we have made a core concept through repeated discussions. And to visualize the results, we created a new hands-on system using a touch panel monitor. Let's display this at the WTP exhibition this year.

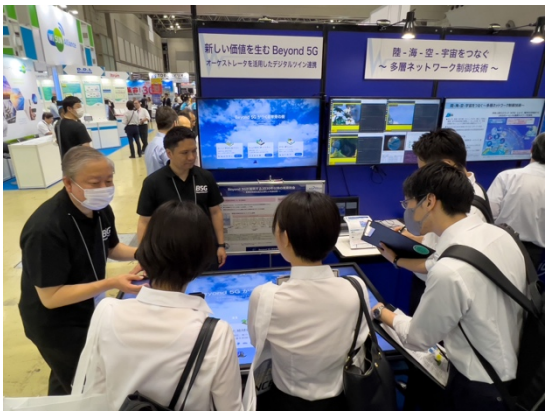
On the day of the exhibition [May 29 (Wed) - 31 (Fri), 2024]

A total of 13 exhibits from Network Research Institute (Wireless Networks Research Center, Resilient ICT Research Center), Social Innovation Unit (Strategic Program Produce Office, ICT Testbed Research and Development Promotion Center), Advanced ICT Research Institute (Center for Information and Neural Networks), and Beyond 5G Research and Development Promotion Unit (Beyond 5G Design Initiative, Terahertz Technology Research Center) were exhibited at the NICT exhibition booth.

In addition, at the seminar, Executive Director of Beyond 5G Research and Development Promotion Unit Hosako gave a keynote speech entitled **"Japanese R & D Strategies in the Beyond 5G Era and the Potential of Terahertz Waves,"** and Director of Beyond 5G Design Initiative Ishidu gave a speech on **"Beyond 5G as a Social Infrastructure - Cross-Industry Collaboration that Creates New Value -"** as a special speech.



This year, Beyond 5G Research and Development Promotion Unit exhibited under the title of **"The Future City created by Beyond 5G - orchestrator that connects industries and creates new values"**. It is an experience tool [*1] using a touch panel monitor where you can experience the flow of solving each social problem by choosing one of three scenarios that focus on social problems **"highly productive agriculture and food loss reduction", "energy conservation and greenhouse gas reduction"**, and **"disaster risk reduction"** by the function **"orchestrator"** in the Beyond 5G architecture.



Many visitors (a total of 250 people) visited the NICT booth from the first day and stopped at the exhibition space of our Beyond 5G unit. **"What is this?"** After explaining the outline of the Beyond 5G architecture and the cross-industry collaboration, everyone experienced it with a serious look according to the narration that flowed from the touch panel monitor. **"It would be great if the world became like this," "How many more years will it be? Am I still alive?" "Infrastructure development is also necessary, isn't**

it?" "Can we participate?" "I want to know more about the mechanism," etc. All the many questions and opinions I received were deeply impressive. For those who asked, I think I answered politely on the spot, but if you want to know more details, please read the **"Beyond 5G/6G White Paper"** [*2] published by NICT. It is also recommended that you go directly to NICT (National Research and Development Agency National Institute of Information and Communications Technology), which has its Headquarters in Koganei City, Tokyo. (See the official website of NICT [*3] for tours and inspections.)

For the first time in 55 years since the nineteen seventy, the Osaka Expo will be held at the artificial island **"Yumeshima"** in Osaka City for 183 days from April 13 to October 13 of the twenty twenty-five. Researchers and engineers from all over the world are conducting R&D every day toward the future Beyond 5G society, and Japanese cutting-edge technologies will also be showcased at the Osaka Expo. NICT will continue to deepen discussions with many people to create a safe, secure, and sustainable world.

Finally, we, Beyond 5G Research and Development Promotion Unit interns **"Sakura-chan"**, also participated in WTP2024 and published the contents of the event on our blog [*4]. If you are interested, please read this as well.

*1 For details of the experience tool, see page 5 of this magazine.

*2 https://beyond5g.nict.go.jp/en/download/index.html

*3 https://www.nict.go.jp/publicity/tour/index.html

*4 https://beyond5g.nict.go.jp/sakura/sakura20240625.html

Report

Event Briefs

- A Summary of Lectures and Other Events Held at Various Locations -

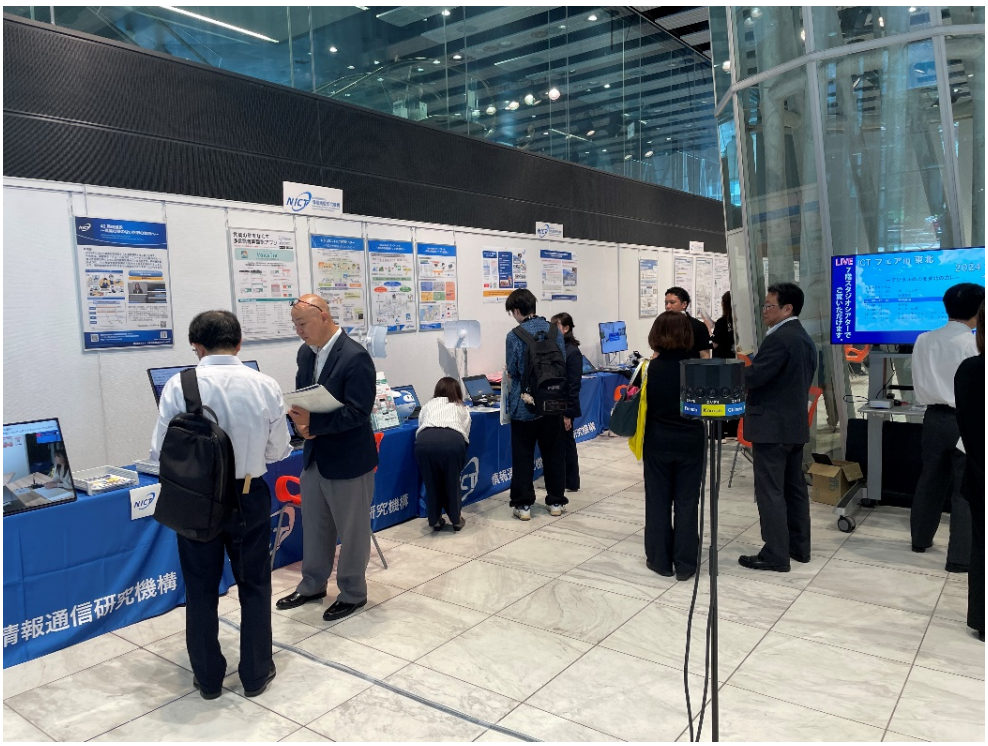
June 11, 2024 (Tue)

Beyond 5G Research and Development Promotion Unit exhibited at "ICT Fair in Tohoku 2024"

The **"ICT Fair in Tohoku 2024"** was held at Sendai Mediatheque, co-hosted by Tohoku Bureau of Telecommunications, Tohoku Information Communication Conference, The Association for Promotion of Public Local Information and Communication, The Council for Info-Communications Promotion Month, and four other organizations. From NICT, Resilient ICT Research Center, Universal Communication Research Institute, and Advanced ICT Research Institute exhibited as well as Beyond 5G Research and Development Promotion Unit. We exhibited VR content that allows you to experience the mechanism of Beyond 5G and touch panel content that allows you to experience how Beyond 5G solves social issues under the title of **"The Shape of a New Society Realized by Beyond 5G."** Many people, mainly companies and organizations in the Tohoku region, experienced it and received impressions and opinions such as **"easy to understand"** and **"want to know more."**

* ICT Fair in Tohoku 2024 （Tohoku Bureau of Telecommunications）

https://www.soumu.go.jp/soutsu/tohoku/hodo/20240426a1001.html



On June 26 (Wed), 2024

Executive Director of Unit Hosako gave a lecture at COMNEXT 2024

"COMNEXT" -2nd Next Generation Communication Technology & Solutions Expo (sponsored by RX Japan Co., Ltd.) was held at Tokyo Big Sight (Koto City, Tokyo), and 12,962 people attended during the session from June 26 to 30. Executive Director of Beyond 5G Research and Development Promotion Unit Hosako gave a lecture entitled **"Future Image of Terahertz Wireless from Standardization Activities"** as a special speech on trends of standardization organizations (ITU-R, ERC, IEEE, ETSI, 3gpp) and R & D funds of Ministry of Internal Affairs and Communications/NICT. In the lecture, the following four points were raised as points that became clear after reviewing the flow of standardization trends so far.

- Regarding frequency allocation, the band around 275 to 325 GHz may be the target.
- The development of the terahertz wave band to 6G may be after WRC-31 at the earliest.
- The use case of Point-to-Point communication, in which the transmitting side and the receiving side move even if the beam is fixed, is the key.
- Before WRC-31, there may be a development of wireless communication of terahertz band based on the IEEE802.15.3-2023 standard as pre-6G.

* COMNEXT -2nd Next Generation Communication Technology & Solutions Expo
https://www.cbw-expo.jp/en-gb.html

* Commentary on Executive Director of Unit Hosako **"It is necessary to share future scenarios from the viewpoint of users and create a momentum to encourage new entries."**
https://www.cbw-expo.jp/ja-jp/blog/article03.html

This text has been translated using "Min'na no Jidou Hon'yaku@TexTra®."

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EVENT EXHIBITION SCHEDULE

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