Facility Sharing Scheme for Beyond 5G R&D: A Comprehensive Guide

(December 1, 2023, Edition)

This is a direct translation from the materials written in Japanese and may be subject to make corrections.

National Institute of Information and Communications Technology

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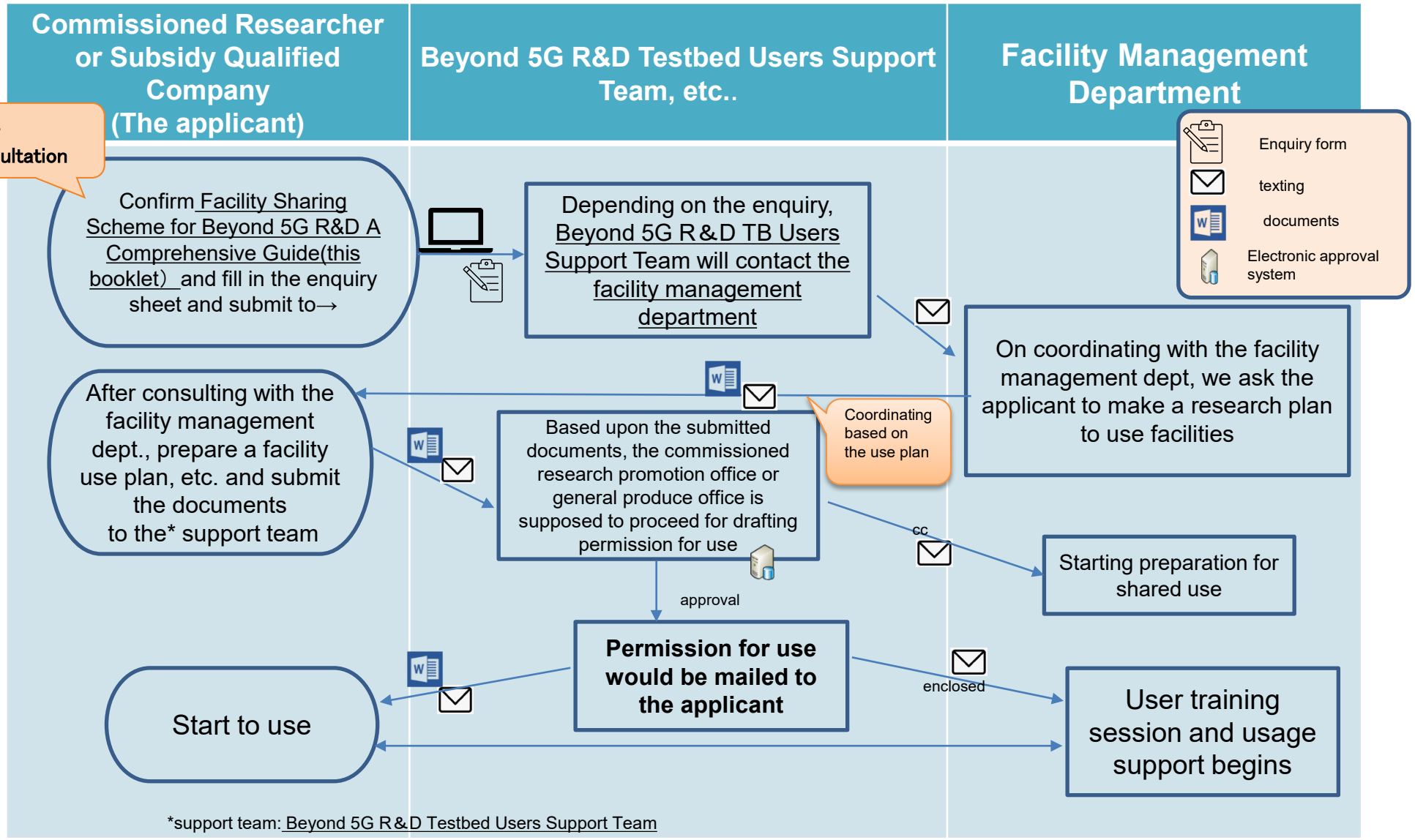
Summary

Use of R&D Testbeds for Beyond 5G Commissioned Research or Subsidy Project

The National Institute of Information and Communications Technology（NICT）has prepared the following scheme to make the Research and Development Testbeds maintained by NICT available to use for Beyond 5G commissioned research or subsidy qualified projects. In principle, when the researcher or developer needs to use the NICT's R&D Testbeds to conduct the research or projects, he/she can use free of charge in accordance with the terms and conditions of the contract for commissioned research or the guideline for issuance of the subsidy established by NICT. To use the facilities, it is necessary to prepare the document "Facility Use Plan" and to adjust the operating schedule. (See P.18 "Procedures for Use of Facilities and Equipment")

- Please note that the use of the facilities may be denied due to safety concerns, appropriate use of equipment or other reasons.
- To avoid conflicts with other users, we reserve the right to refuse urgent or long-term occupancy.
- Since it may take time to make prior arrangements, etc., please contact B5G R&D Testbeds Users Support Team at least 45 days prior to the desired date of use.

From Pre-consultation to Start Using



Available Facilities and Equipment

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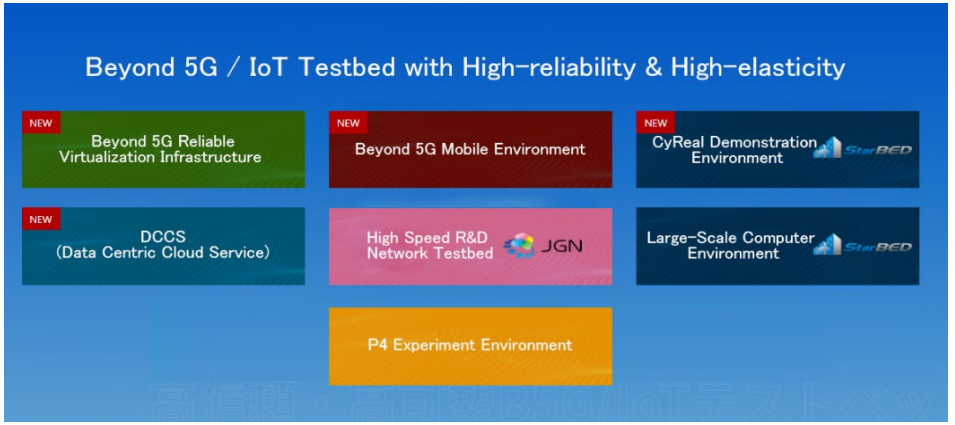
Beyond 5G/IoT Testbed with High-reliability and High-elasticity

overview

NICT has been providing the “NICT’s Integrated Testbed” as a verification platform that enables integrated promotion of technological verification and social verification in the ICT field. In order to ensure the competitiveness of Japan's ICT industry, it is used by industry, academia, and government for research and development, aiming to create an environment for innovation utilizing IoT, AI (artificial intelligence), BD (big data), etc., as a base for open innovation.

During the period of the Fifth Medium to Long-Term Plan (fiscal 2021 to fiscal 2025), in addition to the “High Speed R&D Network Testbed (JGN)” (since 1999) and the “Large-Scale Computing Environment (StarBED)” (since 2002), etc., the “Beyond 5G/IoT Testbed with High-reliability and High-elasticity" has been developed. Furthermore, the experiment environments that enable various R & D and technology demonstrations, etc. in cooperation with each layer of networks, middleware, and platforms that contribute to the realization of Beyond 5G systems would be sequentially provided.

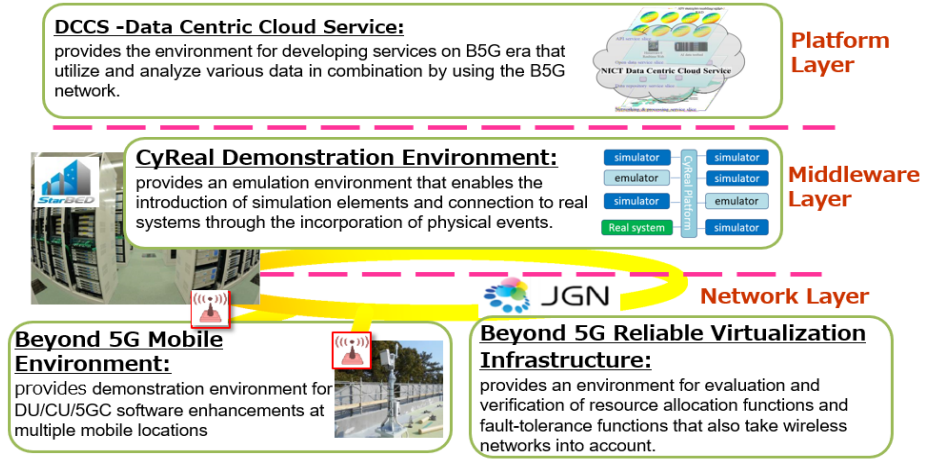


Components of **Beyond 5G/IoT Testbed with High-reliability and High-elasticity**

◆ At the network layer, as a demonstration environment for wireless access, NICT will provide the “Beyond 5G Mobile Environment,” an environment conducive to the development of mobile networks and base stations at NICT Headquarters (Tokyo), Osaka University (Osaka) and Kyushu Institute of Technology (Fukuoka), and the "Beyond 5G Reliable Virtualization infrastructure," an evaluation and verification environment for resource allocation and fault tolerance functions, taking wireless networks, as well as JGN and other backbone networks, into account.

◆ At the middleware layer, we are building an CyReal demonstration environment to promote R & D aimed at integrating cyberspace and physical space. It is a platform for CyReal environment that enables the introduction of simulation elements by incorporating physical events with IoT and CPS in mind. The "CyReal Demonstration Environment" is currently under construction.

◆ At the platform layer, the Data Centric Cloud Service (DCCS) will be provided to promote research and development aimed at the integration of cyber and physical space, and to enable the development of prediction systems and other systems based on data collected independently by users.



Environment provided by **Beyond 5G/IoT testbed with High-reliability and High-elasticity** at each layer

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ICT Testbed Coordination and Planning Office

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Beyond 5G Reliable Virtualization Infrastructure

Beyond 5G/IoT Testbed with High-reliability and High-elasticity

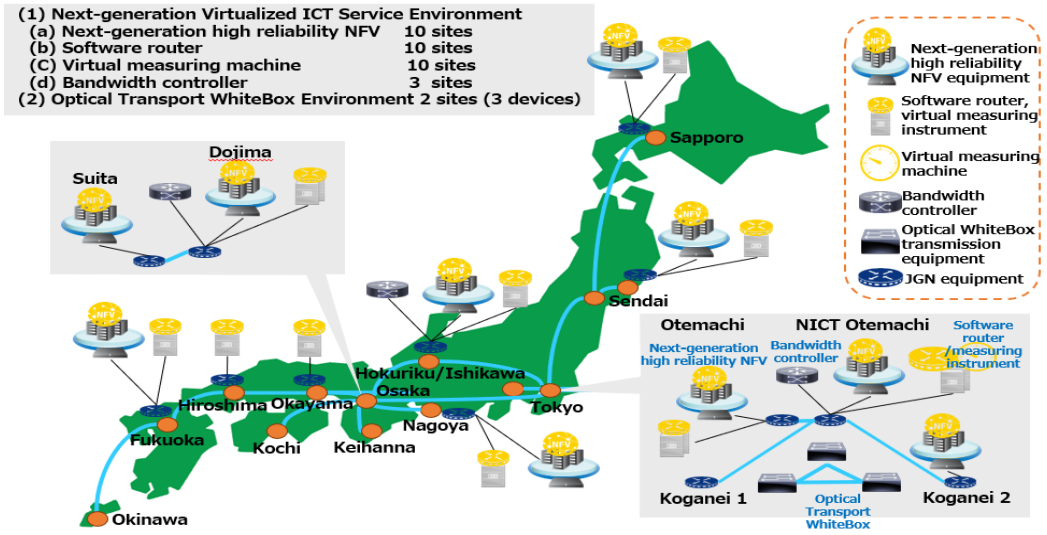
overview

In the Reliable Virtualization Infrastructure, we provide a high-speed, high-reliability **Next-generation Virtualized ICT service Environment** that enables flexible resource allocation through software-enabled network functions and virtualization technology using functions distributed across 10 domestic sites (as of October 2022), and an **Optical Transport WhiteBox Environment** that promotes the advancement of optical transmission technology through disaggregation of optical transmission equipment, hardware and software separation, and openness.

available services

●Next-generation Virtualized ICT Service Environment

- ➢ <u>Next-generation high reliability NFV and software routers</u>
  We provide a verification environment that combines a set of functions deployed at 10 sites nationwide (as of October 2022), preventing service failures due to performance degradation and achieving high reliability through base migration in the event of failure.
- ➢ <u>Virtual measuring instrument and bandwidth control functions</u>
  Upon request, a highly reliable verification environment that can be seamlessly deployed in both virtual and physical environments, and that enables load testing/traffic screening/visualization using measuring instruments would be provided. ※Some of the provided functions are still under development, so please consult us for specific usage.



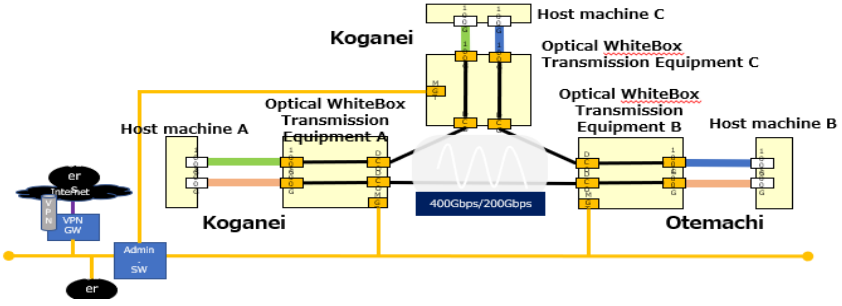
Next-generation Virtualized ICT Service Environment Overall Configuration Chart

● **Optical Transport WhiteBox Environment**

To promote the advancement of optical transport technology through disaggregation, separation hardware and software, and openness of optical transport equipment, we provide a testbed consisting of optical Whitebox transport equipment and broadband optical link

- Three optical WhiteBox transmission equipment
- Optical module for client-side connection
- Optical module for line-side connection
- Broadband optical transport link of 200 Gbps or more on the line side in a specific section

Optical WhiteBox transmission equipment



Optical White Box Environment Overview Chart

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Beyond 5G Mobile Environment

overview

The Beyond 5G Mobile Environment provides Mobile Application Demonstration Environment that enables research, development, and demonstration of technologies centered on the wide variety of applications required for Beyond 5G, Mobile Network Development Environment where mobile core and base station software can be developed using Open5GCore and Free5GC, and Mobile Base Station Development Environment with base station radio areas in the 28 GHz and Sub-6 GHz bands.

available services

- **Mobile Application Demonstration Environment**

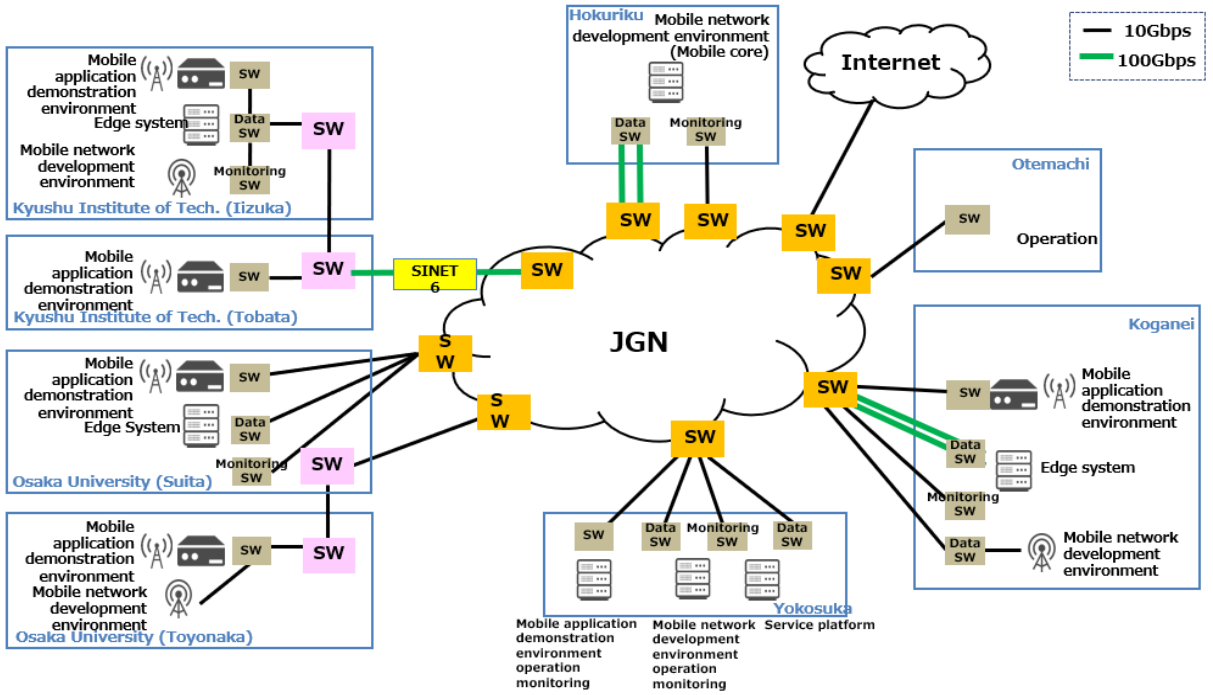
A mobile network environment consisting of base station equipment, antennas, etc. based on Local 5G Stand Alone will be provided at NICT Headquarters (Koganei), Osaka University, and Kyushu Institute of Technology. Using the leased UEs, research, development, and demonstration of technologies focusing on applications that contribute to Beyond 5G networks can be conducted.

※Please contact us for details, as some equipment requires operation or attendance by qualified personnel (qualified radio operators).

- **Mobile Network Development Environment**

We provide a mobile network environment with 5G Stand Alone configuration, including cloud-native base station equipment and antennas using general-purpose servers. Development of mobile core and base station software using Open5GCore and Free5GC enables hardware and software demonstration of DU/CU and core components.

※ Please contact us for more details, as some equipment requires operation or presence by qualified personnel (qualified radio operators) and some software requires a license agreement, such as Open5GCore.



Overview of Mobile Application Demonstration Environment and Mobile Network Development Environment

- **Mobile Base Station Development Environment**

We will provide a mobile system development environment using multiple base stations (2 x 28GHz band (FR2-n257) base stations and 3 x Sub-6GHz band (FR1-n79) base stations) and terminal stations (6 x multi-band UEs) that can be connected to them, installed outdoors or indoors in the Hikarigaoka area of Yokosuka City. We can evaluate the characteristics of radio area formation in the area, demonstrate and evaluate methods to shorten cell search time, handover methods between base stations, and radio resource allocation control methods at the base stations.

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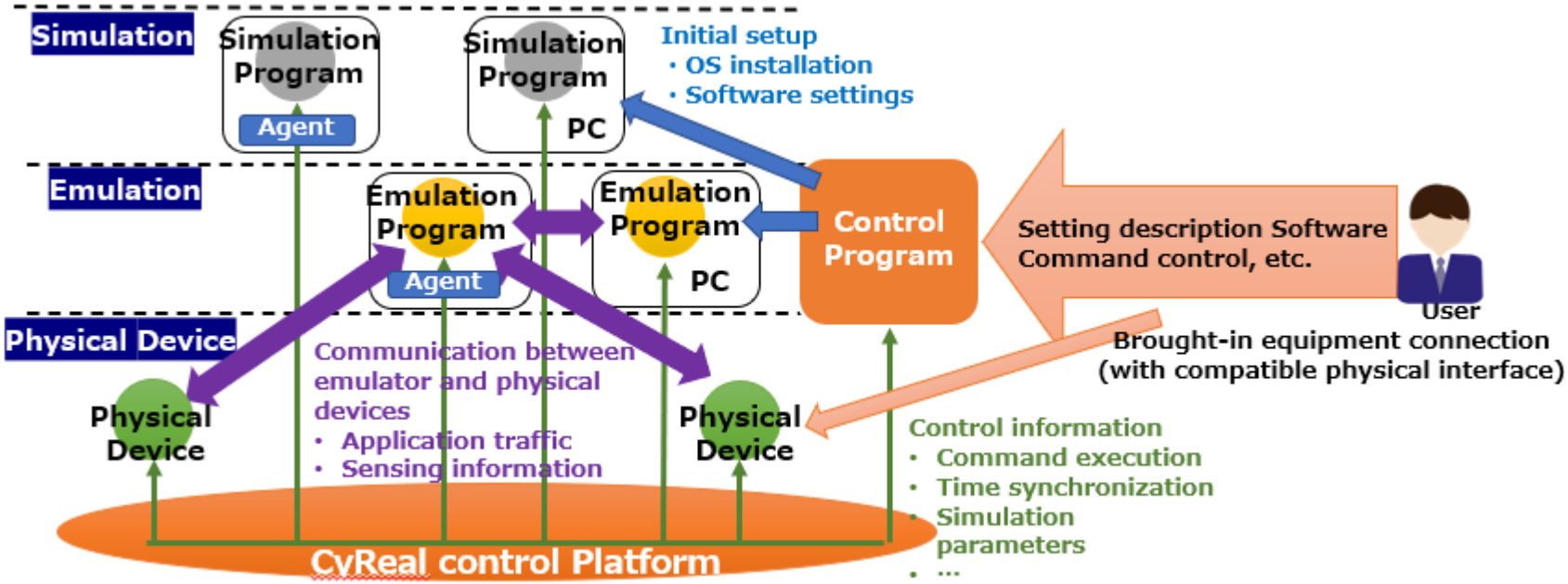
CyReal Demonstration Environment

overview

The CyReal demonstration environment is implemented on StarBED's "large-scale computing environment" and provides a platform for the CyReal environment, which enables the incorporation of physical events with a view to validate technologies related to IoT and CPS by introducing simulation elements.
We have developed the platform that enables cyclic evolution by flexibly introducing new functions, including components of CyReal.

features

In the CyReal demonstration environment, in addition to the ICT implementation itself and the emulator that have been the target of StarBED in the past, information on physical phenomena i.e. movement of people and the temperature and humidity of the space would be calculated by the simulator to provide the necessary information to the emulator and physical device at each step of the experiment, that enables verification by combining elements of different levels of abstraction, such as physical devices, simulators and emulators.



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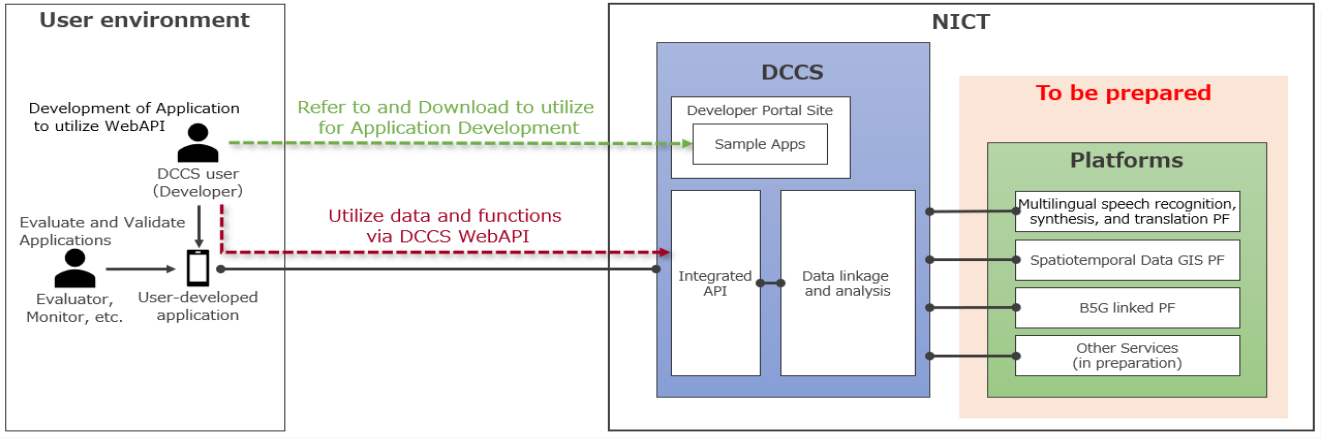
DCCS（Data Centric Cloud Service）

DCCS is a testbed that provides users with a variety of data and functions to utilize it as WebAPI and aims to enable the development of applications and services that utilize such data and functions.

features of DCCS

- Testbed combining various data with Beyond 5G for service creation
- Provides value by leveraging NICT's strengths such as NICT-owned data and advanced technologies
- Development environment for new services using the Beyond 5G network
- Accumulation and sharing of application samples and case studies with users to encourage the sprouting of new services and enable early verification and practical application.
- Develop data and functions in cooperation with external organizations (e.g., through collaboration with testbed subcommittees, joint research, etc.)

system



- Integrated API: Provides a unified endpoint to access data and functions via WebAPI.
- Data Linkage and Analysis: ：Provides the ability to recognize, discover, and predict events (events) that are occurring by combining and analyzing various types of data
- Developer Portal: Provides useful information for development, such as how to use WebAPI and sample applications that serve as a template for application development.
- Platforms: Via an integrated API, a variety of data and functions developed within and outside of NICT will be provided. We plan to provide the platforms listed in the table below.

Platform（PF）	description
Multilingual Speech Recognition, Synthesis and Translation PF (in preparation)	Multilingual speech translation (speech recognition, multilingual translation, text-to-speech) services would be provided
Spatiotemporal Data GIS PF (in preparation)	Mapping and geographic data (town and street boundaries, historical administrative boundaries, etc.) and weather data (temperature, humidity, solar radiation, etc.) and functions to utilize these data would be provided.
B5G Linkage PF (in preparation)	Provides functionality that enables development and verification using the B5G mobile environment without awareness of network layer processing

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High Speed R&D Network Testbed "JGN"

Beyond5G/IoT Testbed with High-reliability and High-elasticity

facilities

JGN, ultra-high-speed research and development network testbed, connects domestic and overseas access points with broadband circuits of up to 100 Gbps, and provides various services such as Layer 2/Layer 3 connectivity, virtualization services, and optical testbeds. The wide-area network environment enables us to verify a wide variety of technologies and services, from backbone networks to applications.

services

- **Network Connectivity (Layer 2/Layer 3) Services** consist of L2 switches as connecting devices and virtualization-compatible switches and routers. 24 access points are installed at domestic and overseas locations, providing Ethernet connection service and IP connection service.

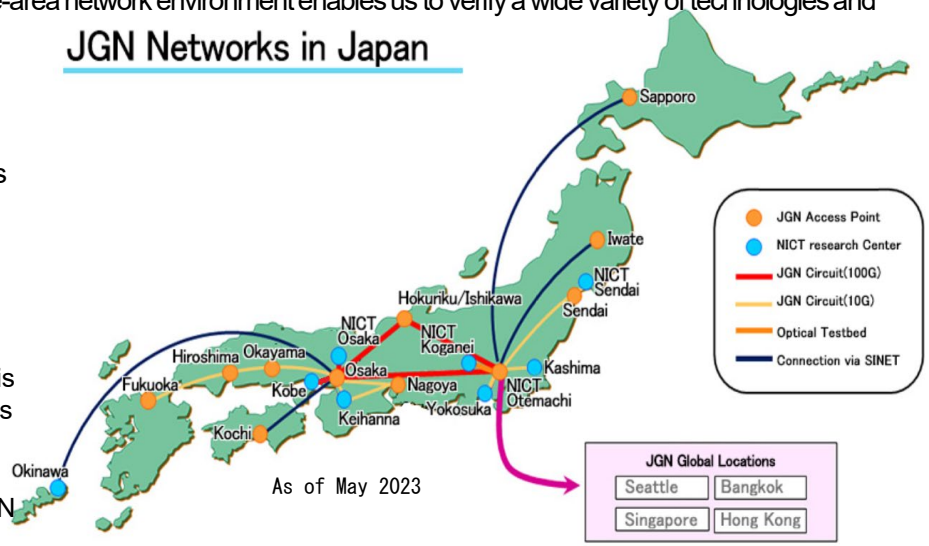
- **Virtualization Services**

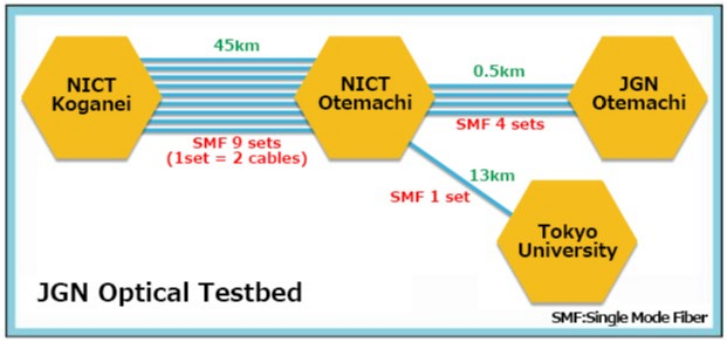
➢ Virtual Server and Storage
You have access to virtual machines (VMs) and storage on the JGN network. The JGN is connected to the JGN at 10Gbps, allowing you to freely install operating systems on VMs (VMware).

➢ Virtual Routers
The virtual routers consists of high-end routers deployed at multiple locations on the JGN network. Users can control the Virtual Router using the management console to build a virtual routing plane (experimental environment) and experiment with network topology optimization and more complex routing. What is more, RIP, OSPF, BGP4, MPLS, various encapsulation functions, etc. are available.

- **Optical Testbed**

Low-loss optical fiber cores are laid between NICT bases (Koganei, Otemachi, and the University of Tokyo) to provide an optical testbed environment where experiments such as terabit-class optical transmission can be conducted, making it possible to conduct various verification experiments and R&D.





Optical Testbed : Technical specifications between each site

experimental environment

●Domestic and overseas experimental sites

JGN operates data centers and other facilities (11 in Japan and 4 overseas) and 9 NICT laboratories and can provide virtualization services at each site as well as network pull-in to the sites.

●Interconnection Network

In addition to Academic Information Network SINET, users can also connect to regional networks interconnected with JGN and It is also possible to connect to the user environment via the Overseas Education and Research Development Network.

JGN Website | High Speed R&D Network Testbed (nict.go.jp)

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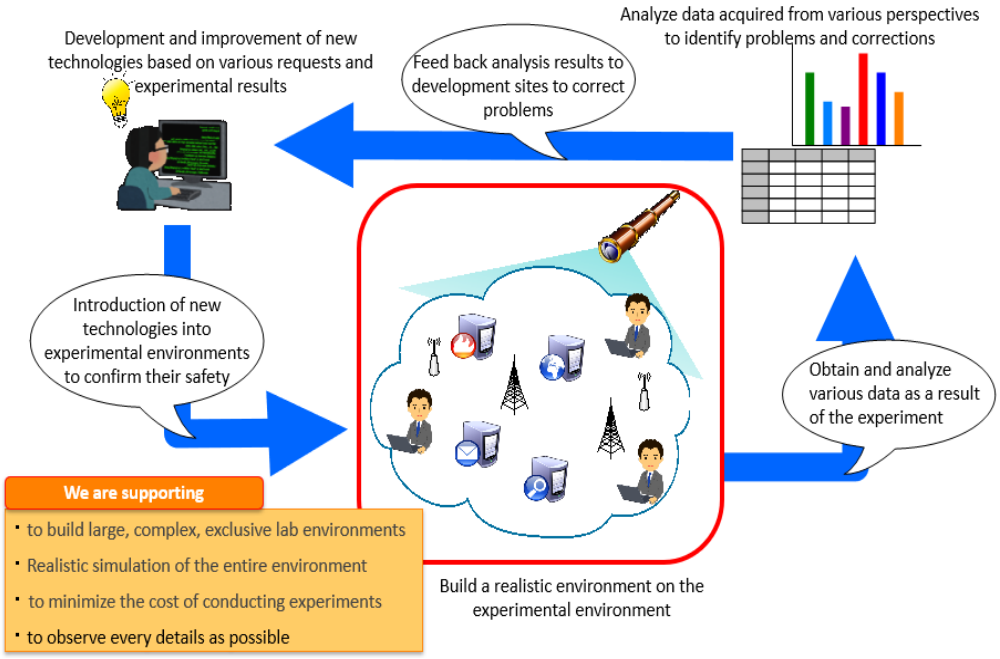
Large-scale Computer Environment “StarBED”

Beyond 5G/IoT Testbed with High-reliability and High-elasticity

overview

Supporting Technology Verification

- StarBED is a large-scale experimental emulation infrastructure consisting of a group of PC servers.
- By providing a large-scale verification environment consisting of general-purpose PC servers and switches, StarBED enables verification using actual hardware and software implementations themselves.
- It is also possible to conduct human resource development and exercises by using implementations with actual user interfaces.



features

- Consists of three parts: experimental node group, management switch group, and experimental switch group
- A network switch group that provides intercommunication between experimental nodes with a backbone of up to 200 Gbps
- An environment that is physically independent from other networks to enable highly reliable experiments and verifications
- Accessible not only internally but also externally via the Internet or VPN, and connectable to external research networks such as JGN and WIDE

StarBED5

The fifth phase of the project as "StarBED5 has been started since 2021. That will further advance the research and development of Internet imitating technology, wireless environment emulation technology, and emulation-simulation coordination infrastructure developed up to the StarBED4 project, with the aim of building a CyReal environment that can seamlessly connect emulation, simulation, and the respective parts realized in the real environment in real time. By generalizing the interfaces that connect each part, we will enable flexible verification by switching the abstraction level of each part between simulation, emulation, and the real environment.

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P4 Experiment Environment

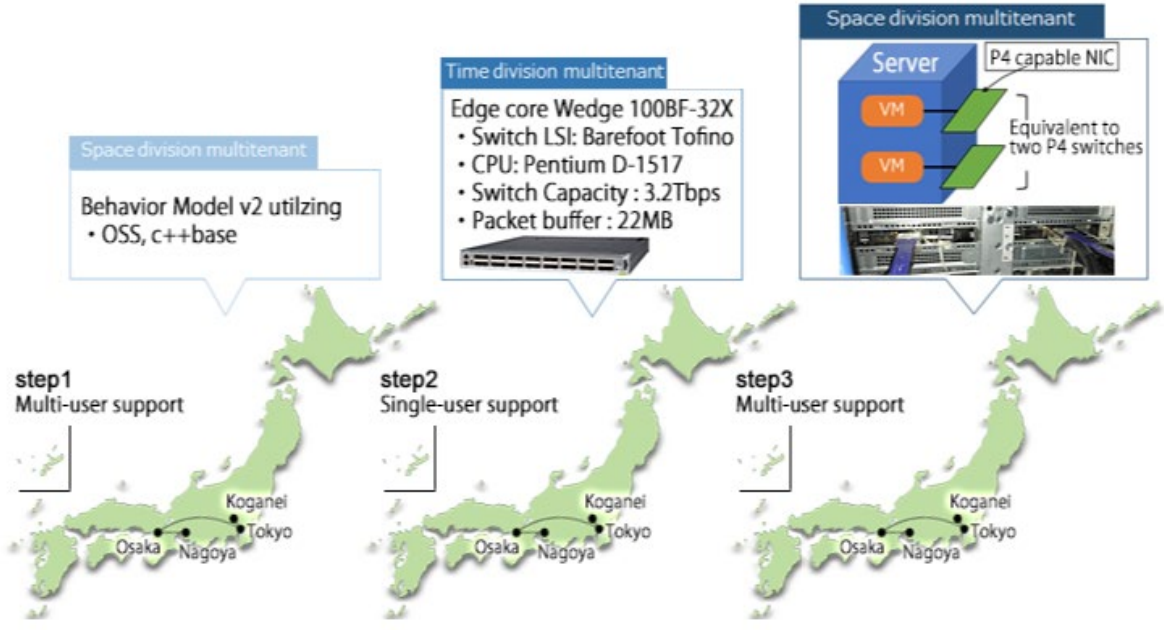
overview

This is an experiment environment for SDN (Software Defined Network) technology using the data plane programming language “P4”. Two types of switches(software switches and hardware switches) and smart NICs will be provided at four locations in Tokyo (Koganei and Otemachi), Nagoya, and Osaka.

P4 stands for Programming Protocol-independent Packet Processors and is a dedicated language (DSL; domain-specific language) in which the data plane of network devices can be programmed. Two description languages, P414 and P416, have been defined. For more information, please refer to the following website. https://p4.org/

available services

- Experiment environment using the software switch BMv2 (Behavioral Model version 2) developed and provided by the P4 Language Consortium
  - ➢ BMv2 and VMs are provided in user-required topologies
  - ➢ Per-user data plane is realized with VXLAN
- Experiment environment with hardware switch Wedge 100BF-32X (limited number of simultaneous users)
- Experiment environment with smart NIC (Intel PAC N3000，which is upgraded in late 2023 to N6000) (limited number of simultaneous users)
- Experiment environment with hardware switches supporting multiple users (to be provided after April 2024)



P4 experiment environment provision service

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Advanced ICT Device Lab Facilities

（B5G Transmission Technology Development Environment ・Electricity, Light and Radio-Wave Conversion-Device Fabrication Platform）

Overview of Facilities

Advanced ICT Device Lab is equipped with a clean room that is maintained in very low dust-free conditions.

There are facilities and equipment and for ultra-fine device pattern formation, high purity deposition using molecular beams and plasmas, ultra-fine processing using ion beams, etc., electrode formation, connection with optical fibers, microscopic shape observation and elemental analysis using electron microscopes, etc., Other facilities and equipment required for various processes and measurements are available. The facility can be used for R＆D of various innovative device technologies using semiconductors and dielectric materials. We provide an all-in-one research environment that enables to conduct integrated research from device fabrication to device evaluation, including substrate microfabrication and material evaluation for device processes and high-frequency and high-speed response tests for device evaluation.

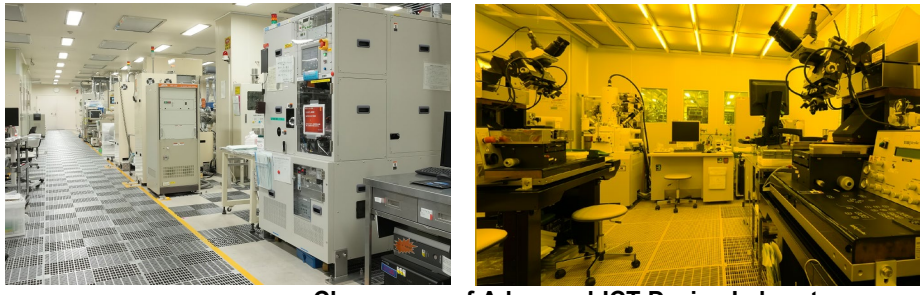
Available Device Fabrication and Evaluation Equipment

Device Fabrication Equipment	Purpose of Use
Electron beam exposure equipment	Resist drawing and exposure by electron beam
Mask Aligner	Photoresist exposure to ultraviolet light
Spin coater	Photoresist coating
EB evaporation equipment	Vacuum deposition and evaporation for metal thin films using electron beams
RF sputtering equipment	Dielectric film deposition by sputtering
Resistance heating evaporation equipment	Vacuum deposition and evaporation of various thin films by resistive heating
Chemical vapor deposition equipment	SiO2 film formation using plasma
Etching equipment	Dry etching of metal thin films, compound semiconductors, and insulating films
Plasma processing equipment	Substrate surface cleaning, removal of organic residue
Infrared lamp heater system	Rapid heat treatment for ohmic electrode formation
Sinter furnace	Ohmic electrode formation by heating furnace
Dicing saw	Substrate cutting
Polishing equipment	Substrate polishing
Draft chamber	Chemical handling (wet etching, resist processing, etc.)

Device Evaluation Equipment	Purpose of Use
Scanning electron microscope	Observation of fine shape and cross-sectional structure
Optical characteristic evaluation device	Transmittance, fluorescence, and Raman spectrum measurement in the infrared region
Ellipsometer	Measuring the thickness of dielectric thin by spectroscopic measurement
Focused ion beam processing system	Fine processing and observation of devices
Film thickness measurement system	Evaluation of local film thickness of stacked structures, etc.
Surface microstructure measuring equipment	Measure surface steps and roughness and microstructure
Compact high-speed terahertz time-domain spectroscopy system	Measurement of material properties in the terahertz range
Ultra-high frequency extender	Jig for ultrahigh-frequency measurement
Optical and electrical spectrum analyzer	Evaluation of scalar and noise characteristics at very high frequencies
Optical Device Tester	Characterization of laser diodes
Optical component analyzer	Measuring Frequency Characteristics of Optical Devices
Sampling oscilloscope	Waveform measurement of high-speed electrical signals
Network Analyzer	Vector characteristics evaluation of ultra-high frequency
Prober System	planar antenna radiation pattern measurement

Features of Facilities, etc.

A group of skilled engineers maintains facilities and equipment to ensure that they are in proper working condition and is prepared to provide standard operating procedures (manuals) for some equipment. Maximum consideration is also given to safety measures for disaster prevention and environmental protection related to waste, exhaust, drainage, noise, etc. Users can concentrate on research and development of devices.



Clean room of Advanced ICT Device Laboratory

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NICT Network Research Institute Advanced ICT Device Laboratory office

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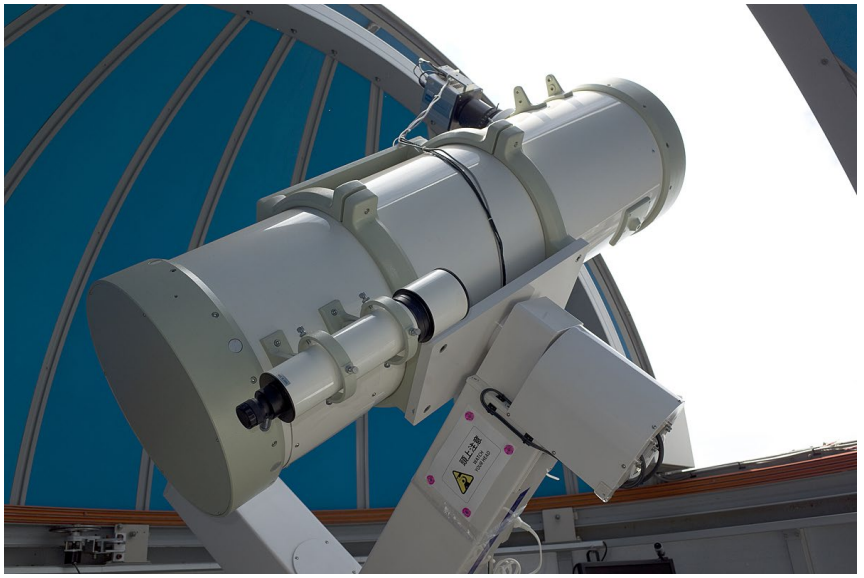
Kashima 35 cm Telescope for Satellite Observation

overview

- NICT installed two telescopes for satellite observation at the Kashima Space Technology Center in 1998 and 2002, respectively, with the primary objective of precise orbit determination of a geostationary satellite by performing optical observation of the geostationary satellite. Furthermore, in 2012, the frame of the telescopes was remodeled so that low-Earth orbit optical communication satellites can be observed.
- NICT can share the one of these satellite observation telescopes with external organizations operating their own geostationary satellites for the following purposes:

➢ To check the accuracy of the operator's own orbit determination method using radio waves.

➢ To check the presence or absence of satellites operated by other organizations in the vicinity of the geostationary satellite.



Kashima 35 cm telescope for satellite observation

features

- The telescope is fixed in a fixed orientation to capture geostationary satellites. The relative positions of the geostationary satellite and the stars in the background of the image are used to determine the azimuth and elevation of the geostationary satellite at the time the image was taken. Our system can measure azimuth with an accuracy of 1/1000 degree.
- The equipment to be used by commissioned researchers is in the dome of the first satellite observation telescope, which consists of a telescope (35cm reflector and mount), CCD camera, GPS clock for recording the time of shooting, PC for camera control, WS for mount control, and WS for image analysis.
- Before using the facility, please inform us of the nadir longitude of the geostationary satellite to be observed via e-mail. etc. Then an observation script is generated, a picture is taken, and the captured image would be analyzed.

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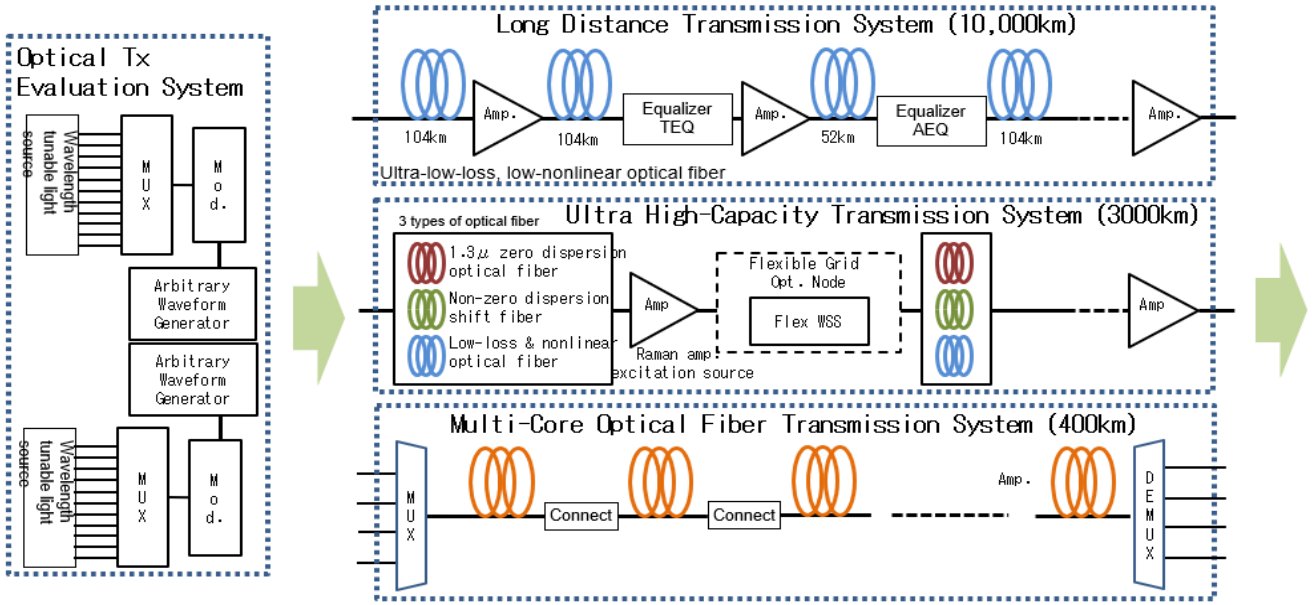
Ultra High-Speed Optical Transmission Experiment Facility

facility overview

- Extremely low-loss, low-nonlinear 10,000 km straight transmission line connecting 100 optical amplifying repeaters
- Flexible grid optical node, 3,000 km x 3 types fiber configuration transmission line
- Transmission lines with 400 km of multi-core fiber that can be freely configured
- Optical transmission/reception characteristic evaluation system for 400Gbps super-channel
- WDM light source: 88 waves at 50 GHz intervals / 112 waves at 37.5 GHz intervals



■ Facility Management Department:
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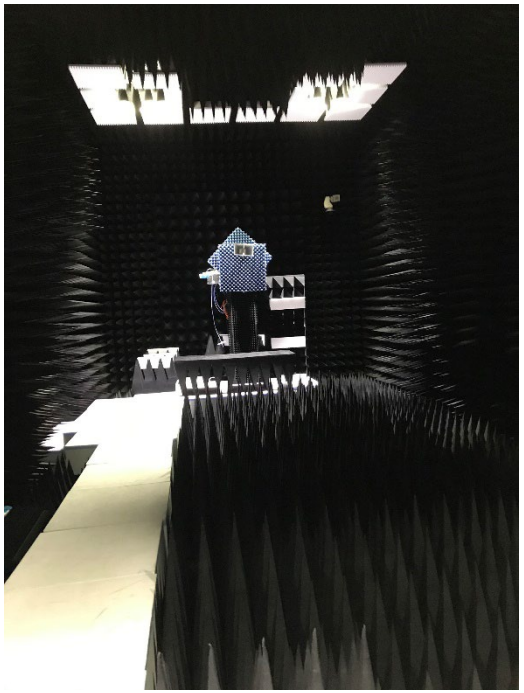
Anechoic Chamber for Microwave Band

RF Measurement Environment

overview

Our anechoic chamber is equipped with a manipulator corresponding to the microwave band for measuring and evaluating antenna characteristics, transceiver transmission characteristics, etc.



specifications

Radio wave absorber:	6 sides
Target frequency:	800 MHz to 110 GHz
Dimensions of chamber:	11.1 m x 4.8 m x 4.5 m floor length width height
Experimental equipment:	Rotary table, antenna jig (positioner), etc.

■ Facility Management Department :
NICT Wireless Networks Research Center Planning Office
E-mail: yokosuka-tb *at sign* ml.nict.go.jp URL: https://www2.nict.go.jp/wireless/

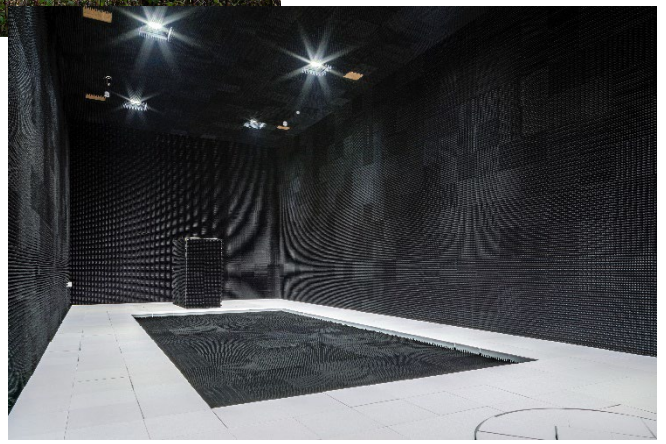
Anechoic Chamber for Terahertz Band

RF Measurement Environment

outline of facilities

Equipped with an antenna positioner and other equipment for measurement of radio waves in ultra-high frequency band, including THz band expected to be used in Beyond 5G systems, this anechoic chamber would be used for measurement and evaluation of antenna characteristics, transceiver transmission characteristics, etc.

B5G anechoic chamber building



B5G anechoic chamber

specifications

- Inner 6 surfaces ：walls, floor and ceiling are covered with absorbers.
  （Floor absorbers can be removed.）
- Target frequency： approx.10GHz～500GHz
- Chamber Dimensions：floor long side 20m x width8.5m x hight7.5m
- Experimental equipment：rotary table, antenna positioner, etc.

■ Facility Management Department：
Planning Office, NICT Terahertz Technology Research Center
E-mail: B5G-EAC-mado *at sign* ml.nict.go.jp

Procedures for Use of Facilities and Equipment

How to Apply to Use NICT Facilities and Equipment

based on the terms and conditions of the contract for commissioned research or the guidelines for issuance of the subsidy

STEP1 Prior Consultation

- **Fill out the inquiry form**：(sorry only available in Japanese language for now）

On receiving your inquiry, "Beyond 5G R&D Testbeds Users Support Team" will contact you. Then you are supposed to consult with the facility management department, and to prepare a "Facility Use Plan" and other documents.

※ Please note that the documents to be submitted vary depending on the facility/equipment.

For the "Facility Use Plan" and other application forms, please visit the website. https://www.nict.go.jp/collaboration/utilization/B5G/

Those application forms are also written in Japanese language only.

STEP2 Submission of Facility Use Plan, Consideration of Use Details and Availability

- Please submit the Use Plan of facilities and required documents to **Beyond 5G R&D Testbeds Users Support Team.**
- After reviewing the documents, we will examine whether the facility is available for use or not, based on the facility's operational status, technical aspects, safety, and other factors. In principle, we will inform you of the screening results within 10 business days.
- A “Notice of Permission for Use” would be submitted on approval.

STEP3 Start of Use

- If you need to set up lines, your own equipment, etc., please operate in the presence of the facility’s management department.
- For safe use of the facilities, you might be required to take a user training course in advance.
- The facilities are available for use from the date indicated on the "Notice of Permission for Use".
- Please follow the instructions of the management department of the facility when using the facility.

STEP4 End of Use and Submission of a Report

- After use, you will be asked to submit a “report”. The report will be made use of improving the facility operation and enhancing its convenience.

Inquiry Form(Japanese only)

Visit our Website on :
https://www.nict.go.jp/collaboration/utilization/B5G/

Contact our Support Team by e-mail at:
NICT_shared_facilities *at sign* ml.nict.go.jp