# NICT's Integrated Testbed

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**Notional Institute of Communications Technology (NICT)**

# Agenda

- Recent updates of NICT's Integrated Testbed
  - "Beyond 5G/IoT Testbed with High-reliability and High-elasticity"

- Our demonstrations on SC22

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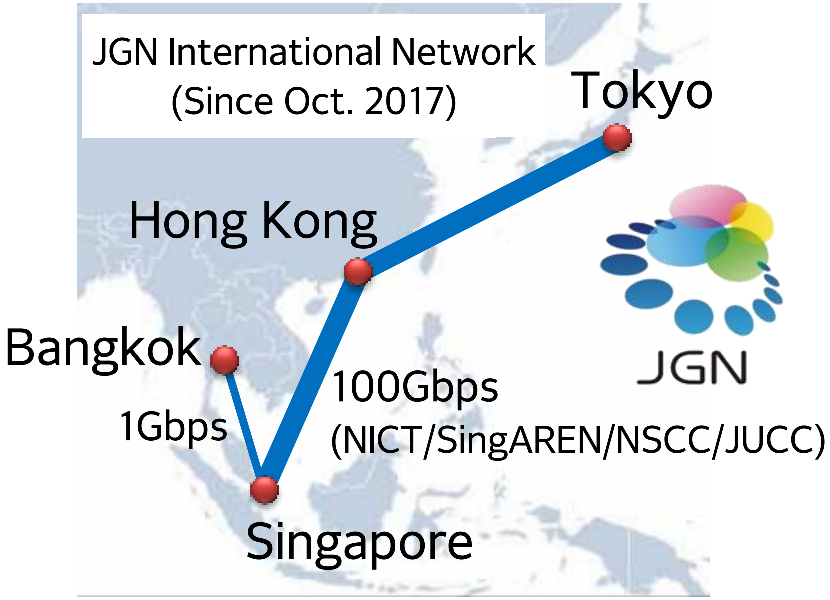
# JGN

- A *Network Testbed* operated by NICT
  - JGN has been operated since 1999
- JGN has International and Domestic networks
  - 100 Gbps: Tokyo-Hong Kong-Singapore (NICT/SingAREN/NSCC/JUCC)
  - 1 Gbps: Singapore-Bangkok
- JGN supports cutting-edge Network Experiments
  - High-Seed App: Uncompressed 8K Video Transmission
  - Time-Sensitive App: Next-Generation ICT-supported Surgery, etc.
- We have been collaborating with NII/SINET to extend Network Reachability in Japan



# JGN Global Networks: Connections

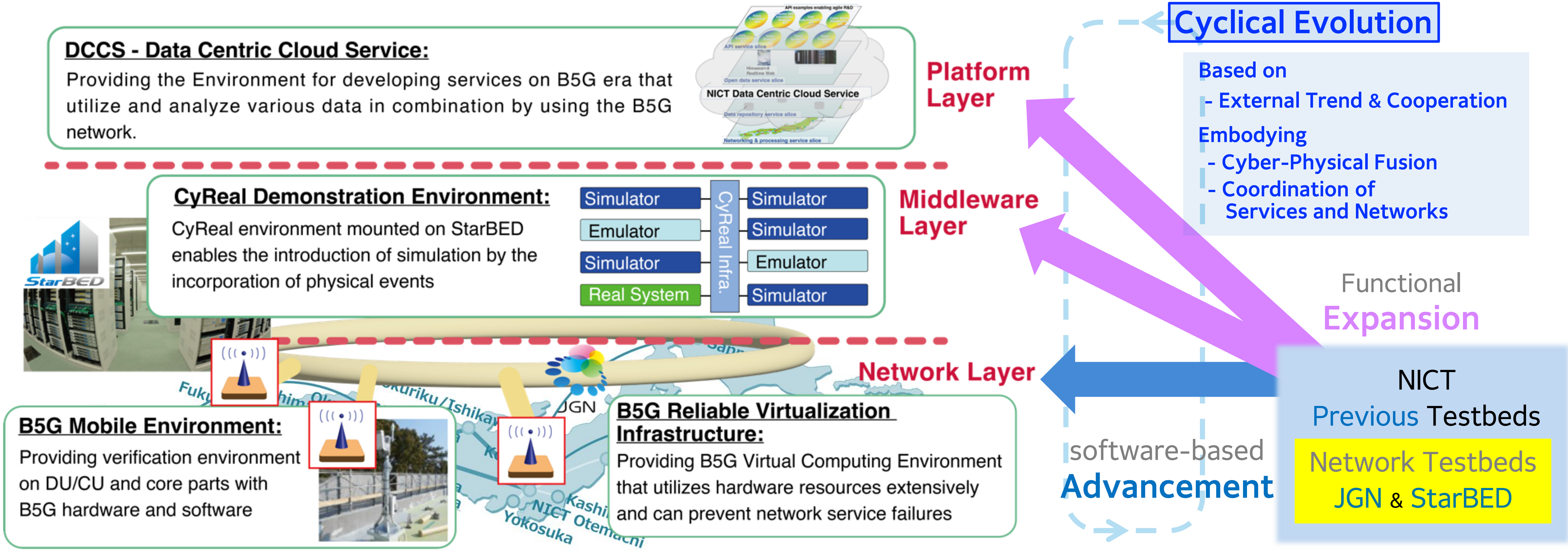
# StarBED

- A cluster of 1000 or more PCs dedicated to diverse huge-scale verifications
  - Hardware-as-a-Service
  - Common OS and software work
  - Realtime network emulation
  - Can allow “ERROR” by separation from Internet
  - Can verify behavior of malware in isolated environment

# Beyond 5G/IoT Testbed with High-Reliability & High-Elasticity

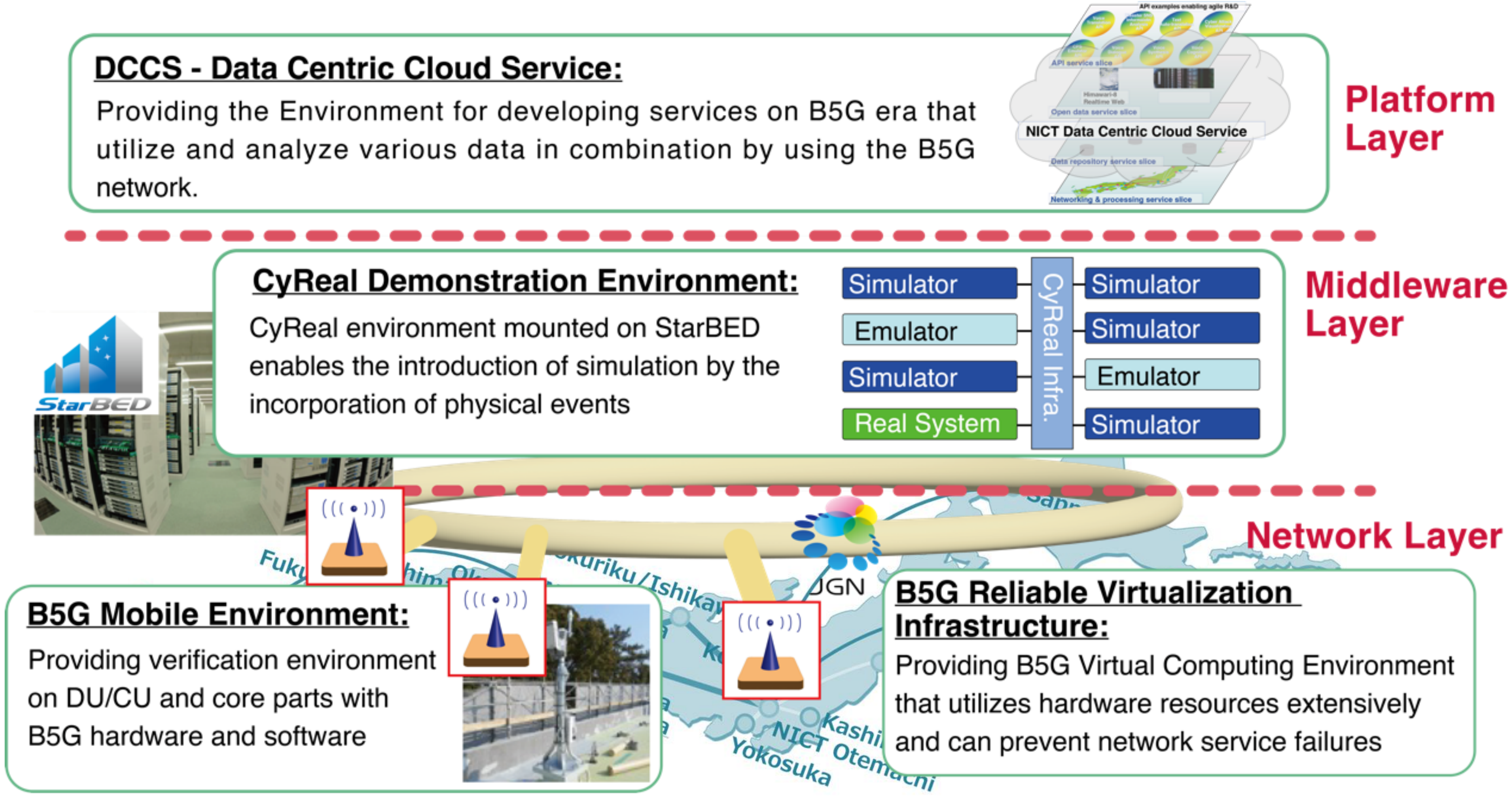
- NICT launched Beyond 5G/IoT Testbeds Services from Oct. 2022.

Goal: Accelerating Research & Development and Social Demonstration toward the Realization of B5G through Collaboration among Diverse Players using Testbed



# Beyond 5G/IoT Testbed with High-Reliability & High-Elasticity

- Flexible and Expandable. In addition to Wired and Wireless Infrastructure, Data Analysis and Radio Environment Simulation are also assumed for Verification.
- Some of the Facilities are also located at External Universities, emphasizing Collaboration between Research Institutions and involvement with Local Industries.




**DCCS**: Implemented on the StarBED and can be used remotely via JGN.

**CyReal Demonstration Environment**: Implemented on the StarBED and can be used remotely via JGN.

**B5G Mobile Environment**: Mobile environments connected to JGN are installed in Tokyo, Osaka and Kyushu, and some core facilities are installed in Hokuriku.

**B5G Reliable Virtualization Infrastructure** : Implemented on JGN and can be demonstrated across multiple JGN sites in Japan.

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# B5G Reliable Virtualization Infrastructure

- **Next-Generation Virtualized Service Env.**
  - A high-speed, high-reliability Next-generation Virtualized ICT Service Environment using Software-based Network Functions and Virtualization technology, enabling a flexible resource allocation

- **Optical WhiteBox Environment**
  - An Optical Transport WhiteBox Environment that promotes the advancement of Optical Transmission technology through the disaggregation of Optical Transmission Devices and the separation/openness of the Hardware/Software

- **Next-Generation ISP/Cloud Demonstration Env.**

  From April, 2024

  - A Testbed that provides the virtualization technology necessary to conduct ISP and Cloud Services Business

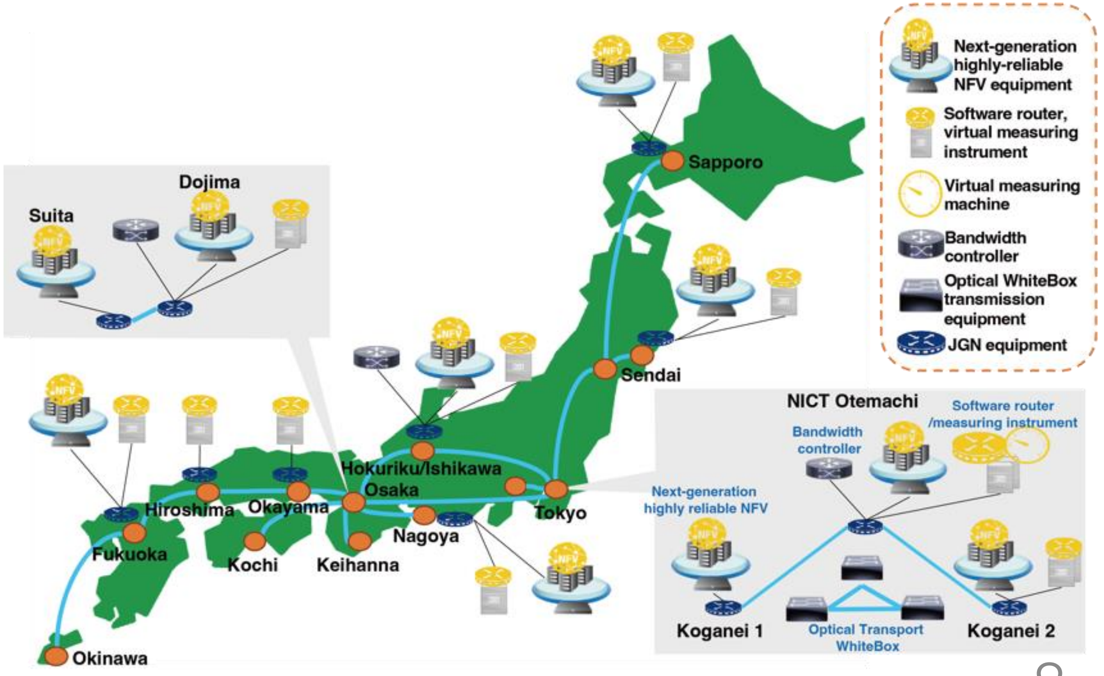
■ B5G Reliable Virtualization Infrastructure consists of Two Parts

1. Next-Generation Virtualized Service

| | |
|---|---|
| (1) Next-Generation Reliable NFV | 10 sites |
| (2) Software Router | 10 sites |
| (3) Virtual Measuring Instrument | 1 site (Instrument on VM) |
| (4) Bandwidth Controller | 3 sites |

2. Optical WhiteBox Environment

| | |
|---|---|
| (1) Optical WhiteBox Switch | 2 sites |
| (2) Broadband Optical Transport Lines | |

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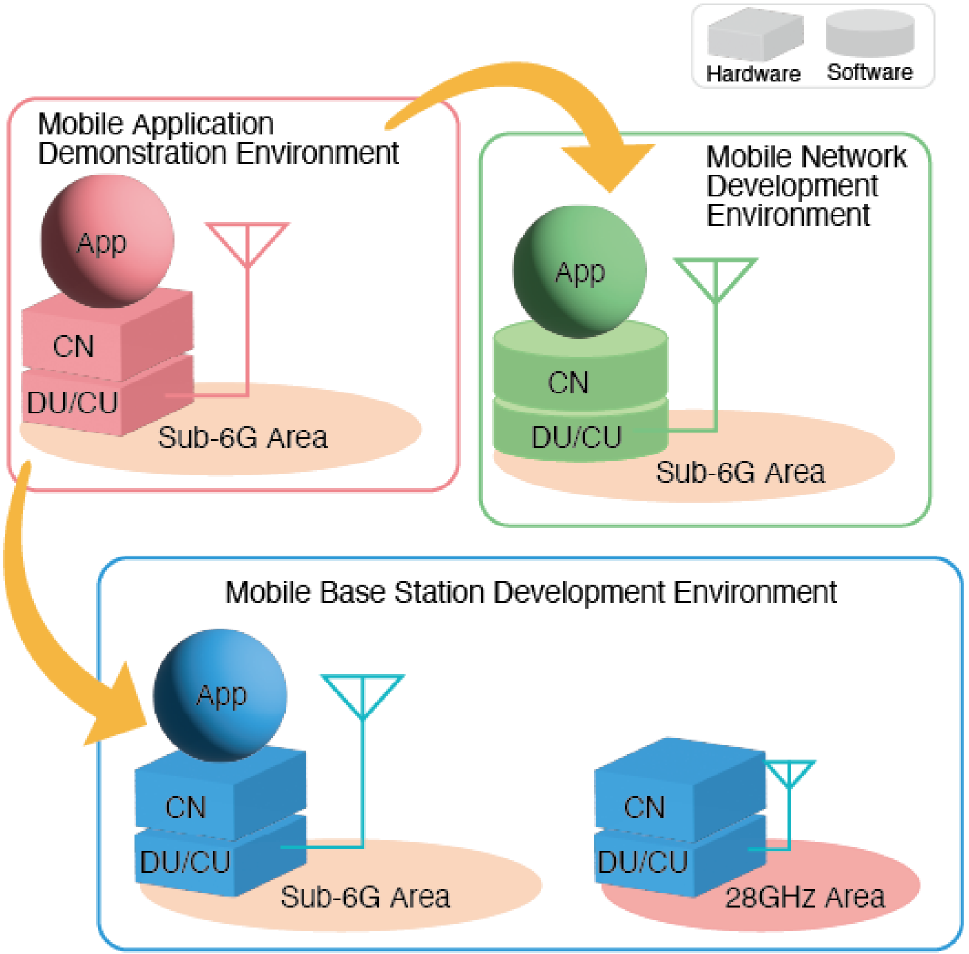
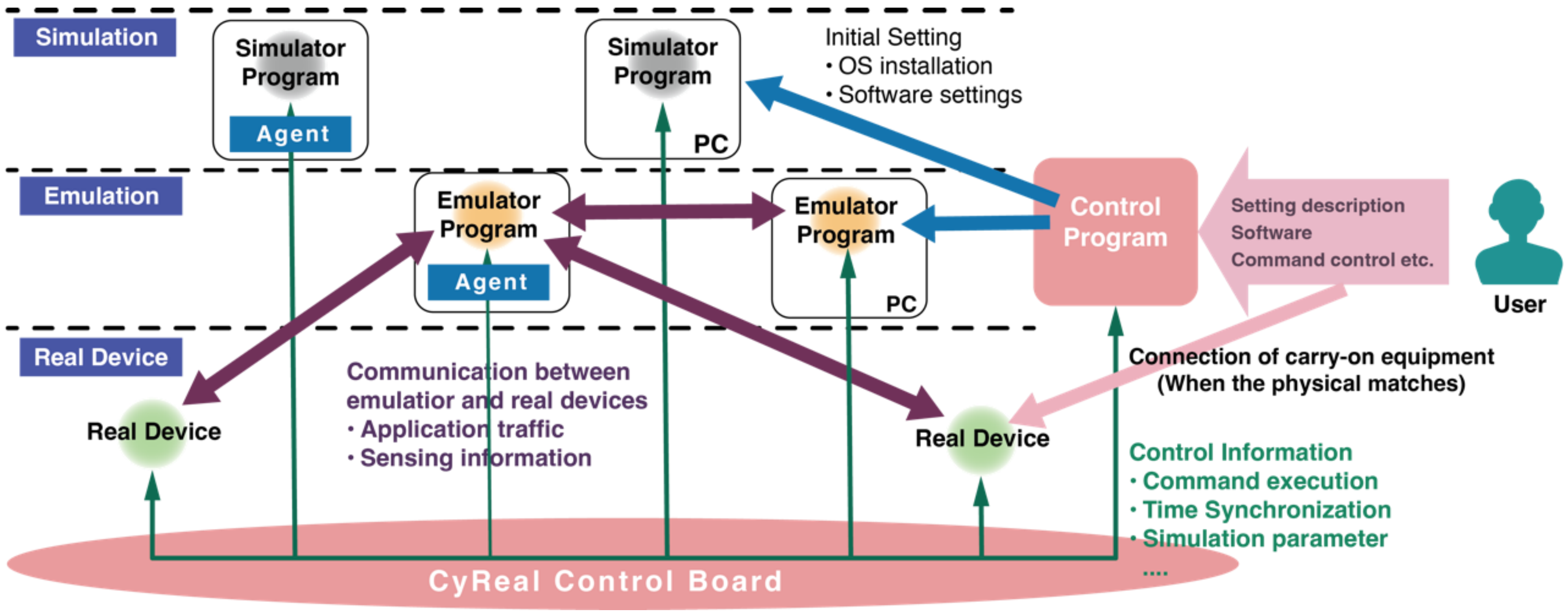
# B5G Mobile Environment

- **Mobile Application Demonstration Environment**
  - Mobile network environments provided from NICT Headquarters (Koganei), Osaka University, and Kyushu Institute of Technology, consisting of Base stations and Antennas based on Private 5G Stand Alone.
    By using leased terminals, users can research, develop, and demonstrate technologies like applications contributing to Beyond 5G network.
- **Mobile Network Development Environment**
  - A mobile network environment with a 5G Stand Alone configuration, including Cloud-native base station equipment using General-purpose servers and Antennas. By developing mobile core and base station software using Open5GCore and Free5GC, it is possible to verify DU/CU and core parts using hardware and software, respectively.
- **Mobile Base Station Development Environment**
  - A demonstration environment for mobile systems using multiple base stations (28 GHz band and Sub-6GHz ) installed outdoors or indoors in Yokosuka City and Terminals connecting to base stations.



# CyReal Demonstration Environment

- Easy Install and Settings
  - Users can install and run the necessary programs on StarBED PCs.
  - The Environments are automatically built with input on OS install, VM setup and network environment
  - Users can install Linux and other software to control program behavior and change OS and application settings.
- Communications via Cyber Control Board
  - Via Cyber Control Board, Information can be exchanged with Elements in Simulators, Emulators and Real Devices
  - Each element needs to be controlled by a command from the Agent using SSH or communicate using a dedicated API
  - The communication interface for control can be defined by the user, also assuming wireless emulation applications*

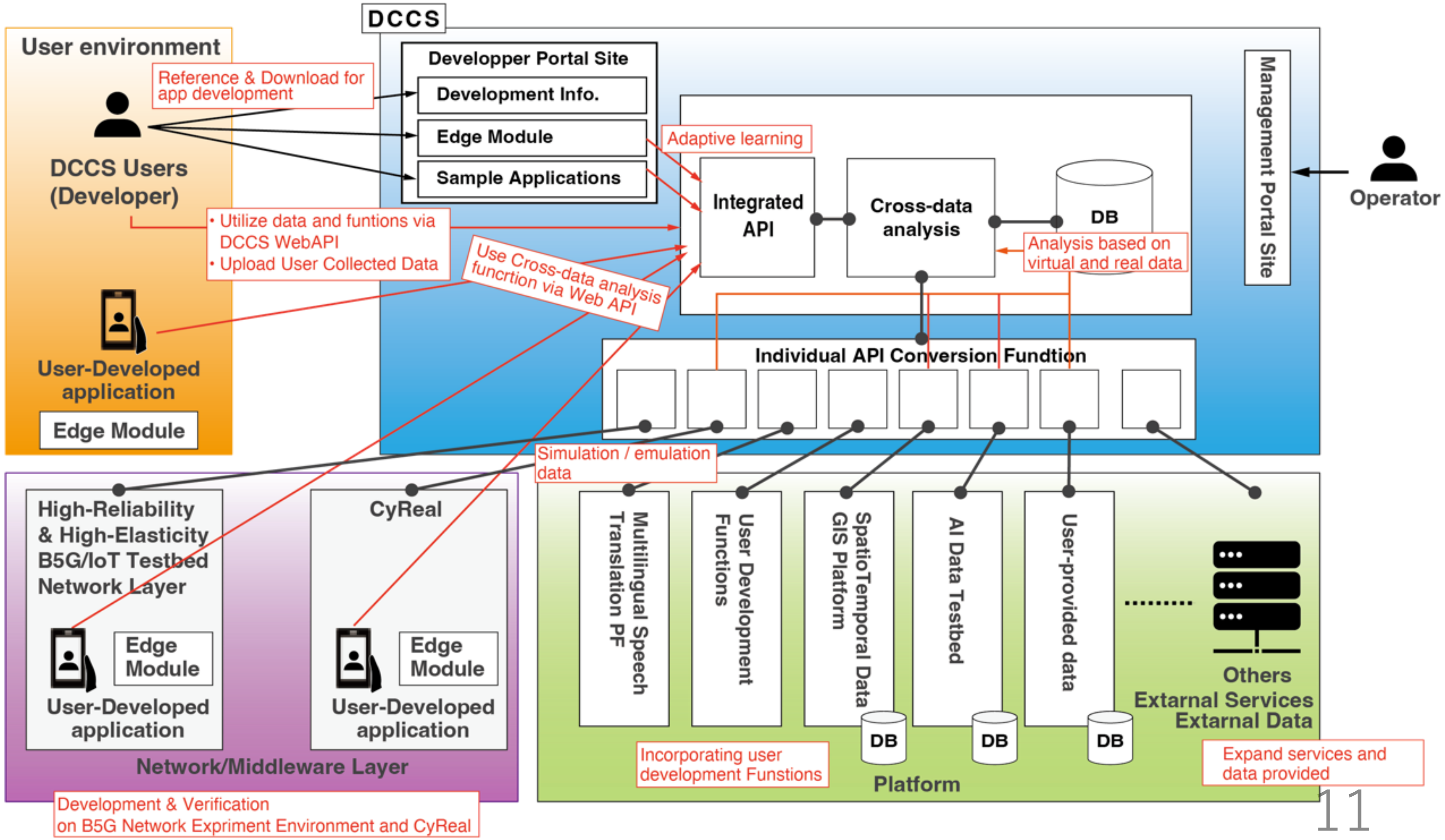



(*) This research has been conducted under the contract "R&D for the realization of high-precision radio wave emulator in cyberspace" (JPJ000254) made with the Ministry of Internal Affairs and Communications of Japan.

# Data Centric Cloud Service – DCCS –

- Provided Data and Functions as Web API
  - Diverse Data and Functions to utilize it are provided as Web API
  - Users can develop Application and Services by utilizing these Data and Functions
  - User-owned data can also be uploaded and applied to DCCS for various processing

- APIs and Developer Portal
  - The APIs are Python-base and easy to code
  - Support Application Development by providing the Developer Portal with Sample programs and documentation for API specifications and usage, etc.



# Agenda

- Recent updates of NICT's Integrated Testbed
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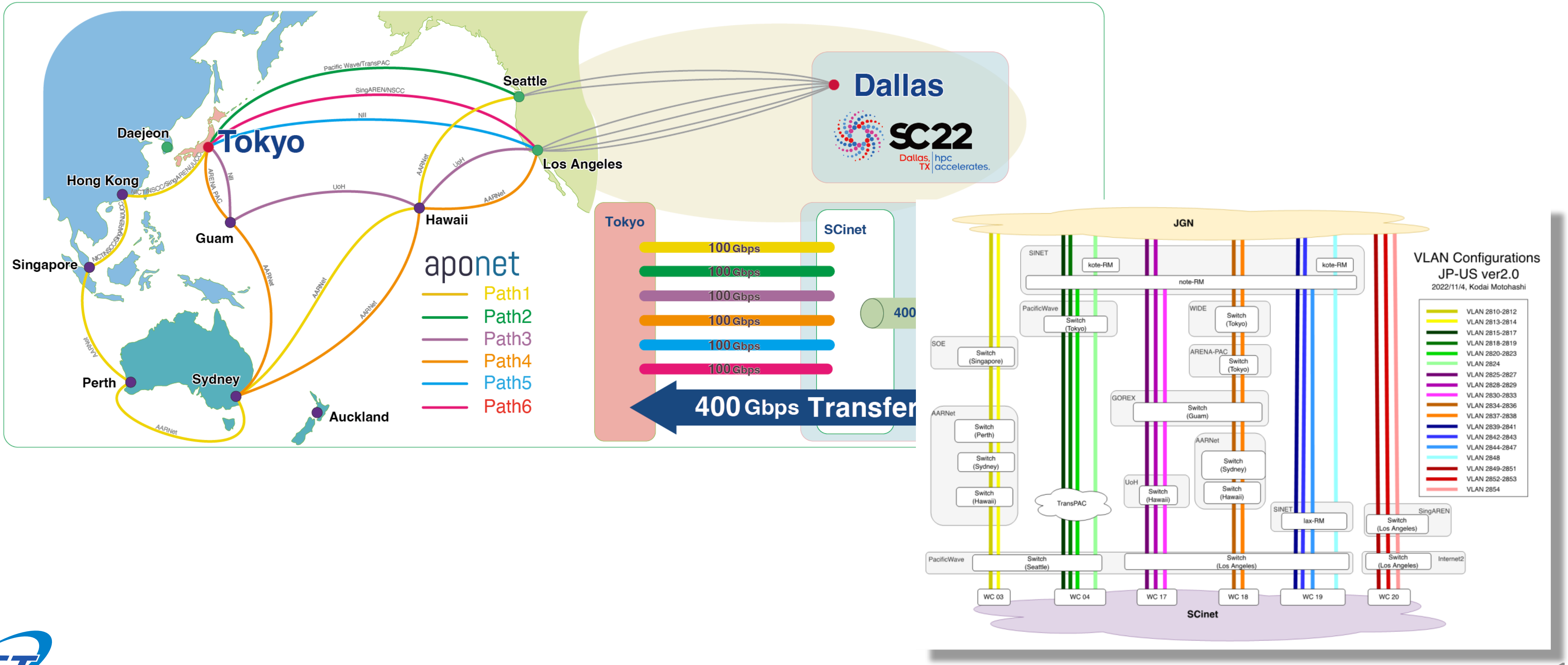
# SC22 NICT Demonstrations

- The 400Gbps Transfer experiments were Successfully carried out.

  With Six 100Gbps Paths between *Dallas* and *Tokyo* over the Pacific Ocean and the US.



# Demonstrasions on NICT booth

6 of 29 network research demonstrasions on SC22 were performed on NICT booth

| | Organization | Title/NRE title | |
|---|---|---|---|
| 1 | IPA | Full 400Gbps E2E Data/Video Transfer | NRE-023 |
| 2 | Kanagawa Instirute of Technology/Daido University/University of the Ryukyus/ Miharu Communications Ind. | Uncompressed 8K video processing on edge computing | NRE-022 |
| 3 | Keio University/Alaxala/UT Dallas | Conceptual demonstration of the reconfigurable in-network security sensor network (REINS network) | NRE-026 |
| 4 | NICT/JAXA/intelligent light/CLEALINK technology | In-transit remote visualization via HpFP (High-performance and Flexible Protocol) | NRE-029 |
| 5 | NICT | High Bandwidth U.S.-Japan Traffic Test Using Virtualized IXIA IxNetwork | NRE-027 |
| 6 | NICT | QEMU/KVM VM Migration Test Between U.S. and Japan Sites | NRE-028 |
| a | Kyushu Institute of Technology, KDDI Research, Inc., CCNY | F-CPS : Floating Cyber-Physical Systems for Local-oriented Services and its Global Federation | |
| b | NTT Communications | Kamuee, a High Performance Software Router | |
| c | Osaka University | An On-time Data Transfer Framework in Cooperation with Scheduler System | |
| d | NICT | Introduction of NICT and NICT's Integrated Testbed | |

# Demonstration by IPA

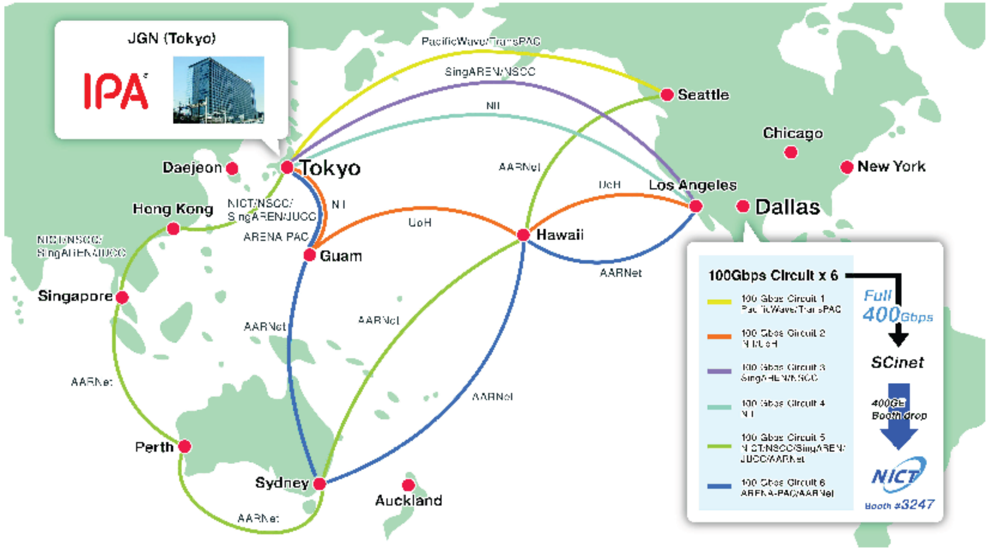
- **NRE-23:Full 400Gbps E2E Data/Video Transfer**

  End-to-end 400 Gbps transmission between Dallas and Tokyo

  - Used 6 100Gbps paths between Dallas and Tokyo
  - Transmitted 80Gbps traffic for each path on average
  - Succeeded for long-term stable 400Gbps transmission by aggregating 6 paths

## The experiment for 400Gbps transmission over Trans-Pacific Rim

### Abstract




We will use six 100Gbps networks over Trans-Pacific Rim connecting SC22 venue and Japan with end-to-end connectivity. The connection will be used for 400Gbps traffic transmission, 8K / 4K / compressed / uncompressed video transmission, and combination of them all. The traffic for this experiment, unlike typical internet traffic which is a large volume of communication originating from a large number of users, transmit a large volume in a single or small number of streams which are more susceptible to various factors.

Each of six networks for this experiment has different traffic transmission characteristics due to its network route, transmission distance, delay, and equipment. When using end-to-end connectivity to transmit traffic, the influence from these elements are unavoidable.

The purpose of this demonstration is to clarify the problems that can arise from implementing traffic transmission with a single or a small number of high-capacity streams in such realistic situations.

### Contributors

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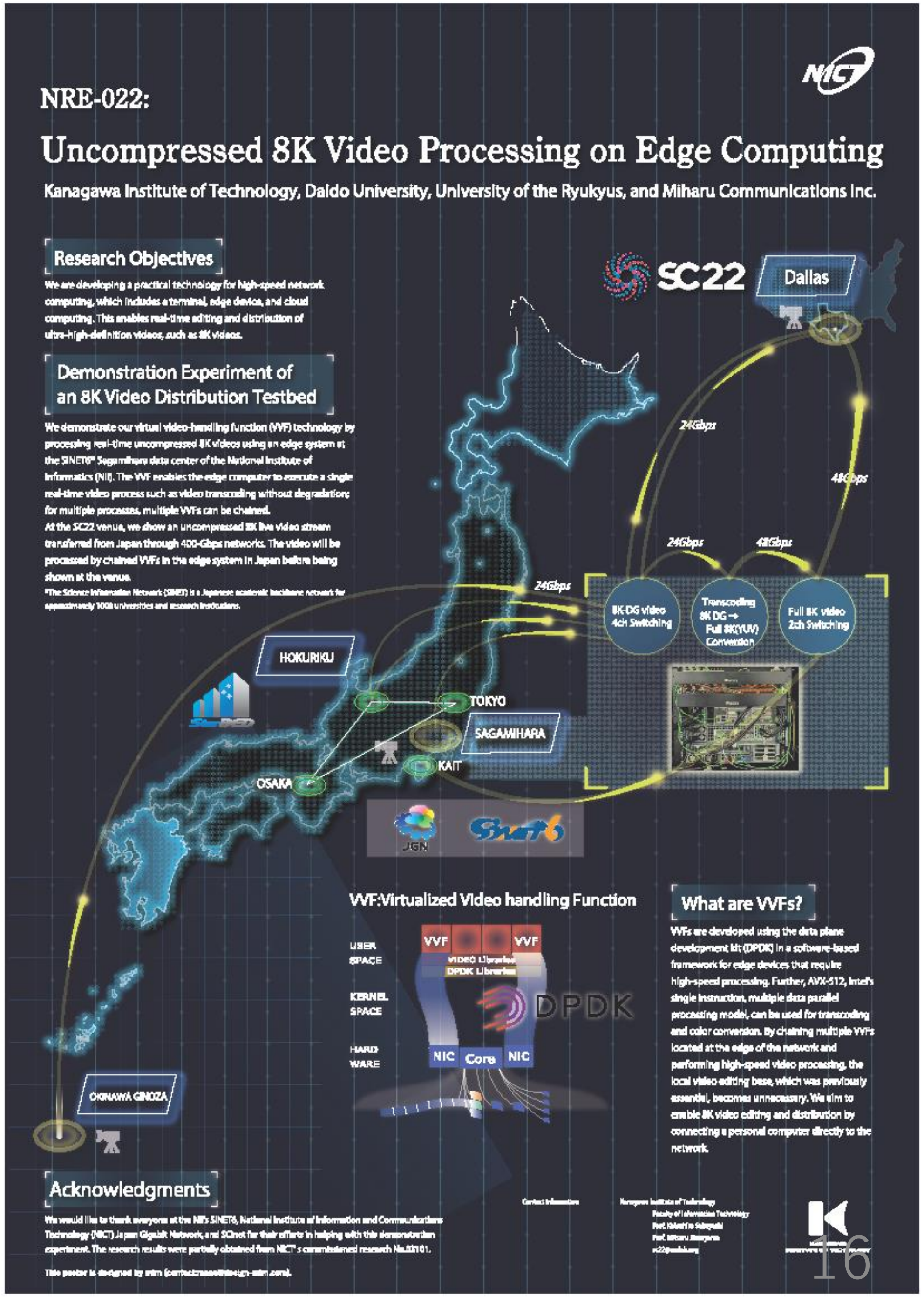
# Demonstration by KIT etc.

- **NRE-22:Uncompressed 8K video processing on edge computing**

Real-time editing and distribution of uncompressed 8K video

- Uncompressed 8K live video stream was transferred from Japan to SC22 venue and shown.
- The video was processed/edited in real-time by chained VVFs (Virtual Video-handling Functions) in the edge system in Japan before being shown at the venue.



# Demonstration by NICT (1)

## ●NRE-27:High Bandwidth U.S.-Japan Traffic Test Using Virtualized IXIA IxNetwork

Performance test of network testing equipment (IXIA IxNetwork) of NICT's testbed

- Used software router servers (SwRS) on Dallas and Toyko
- Tested using the five paths between Dallas and Tokyo
- The frame size of sent packets was 1522 byte

Latency was not measured correctly.
(Waiting for manufacture's fix)

| Path | L1TX (Gbps) | L1RX (Gbps) | RX pps | Latency:min / avg / max(ms) | Loss |
|---|---|---|---|---|---|
| Path1 | 80.05 | 73.34 | 5.95M | -302.27 / 239.56 / 795/61 | 8.42% |
| Path2 | 80.052 | 80.05 | 6.49M | -493.93 / 239.56 / 795.61 | 0.062% |
| Path3 | 80.06 | 80.04 | 6.49M | -477.78 / 68.82 / 651.64 | 0% |
| Path4 | 80.05 | 73.26 | 5.94M | -330.87 / 207.52 / 661.20 | 8.38% |
| Path5 | Not used | | | | |
| Path6 | 80.06 | 80.04 | 6.49M | -403.75 / 48.84 / 669.86 | 0.08% |
| Combined | 395.64 | 384.02 | 31.13M | -498.07 / 121.42 / 801/80 | 2.93% |

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# Demonstration by NICT (2)

## NRE-28:QEMU/KVM VM Migration Test Between U.S. and Japan Sites

Performance test of NFV migration between Dallas and Tokyo

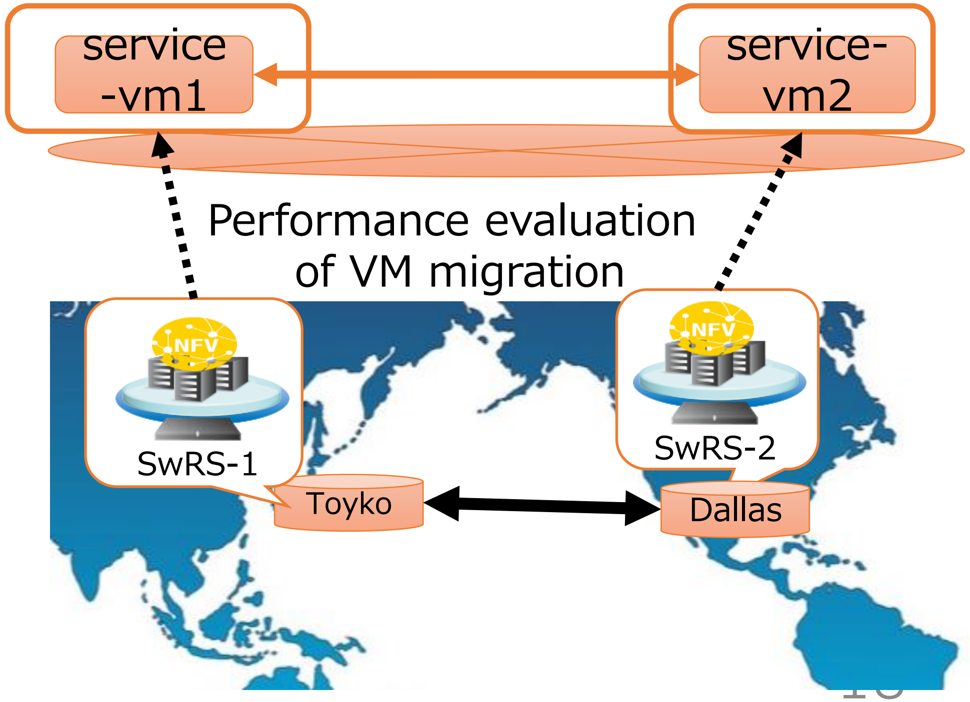
- The file size of NFVs was 25G bytes
- Used 4 of 6 paths

Future tasks:
- Analysis in detail
- Improve performance

Difficult to keep throughput of TCP due to effects of packet loss and latency

Migration performance depends on throughput of TCP

| Path | Throughput | Migration time |
|---|---|---|
| 1 | 55.9 Mbits/sec | 54 min 31 sec |
| 2 | 159 Mbits/sec | 22 min 26 sec |
| 3 | 128 Mbits/sec | 26 min 41 sec |
| 4 | 173 Mbits/sec | 20 min 12 sec |



# Awarded Spirit of Innovation Award from SCinet


AARNet, APONET, ARENA-PAC, CENIC, Ciena, Cisco, HARNET, Internet2, KISTI,

**NICT**,

NII, Pacific Northwest Gigapop, REANNZ, SingAREN, TransPAC, University of Hawaii, Verizon

(Blue organizations are members of APOnet)

The research innovations are being **demonstrated at the NICT booth** at SC22 this year, and feature several experiments that will leverage International connectivity and technology support being provided by the collocating partners. These demonstrations will transmit data and video streams of various qualities across a multi-continental path, use cloud and edge computing approaches to perform at scale video processing and measuring and monitoring of the network infrastructure, and use this intelligence to dynamically control the network path.

https://sc22.supercomputing.org/2022/11/15/scinet-spirit-of-innovation-award-recognizes-17-contributors-role-in-supporting-international-science-activities-for-sc22%EF%BF%BC/

# Summary

- NICT launched Beyond 5G/IoT Testbeds Services from Oct. 2022.
  - This aims to Accelerating Research & Development and Social Demonstration toward the Realization of B5G through Collaboration among Diverse Players using Testbed
  - The Network Layer has been refined by software technology
  - CyReal Demonstration Environment was implemented as the Middle Layer
  - As a Platform Layer, DCCS enable development of applications and services using various data and functions
  - We have been embodying the B5G/IoT Testbed by Cyclical Evolution
- Our demonstrations on SC22