R&D Testbed toward Beyond 5G Network

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https://testbed.nict.go.jp/english/

Contents of This Talk

- NICT's testbed for R&D
- Experimental applications
- Towards Beyond 5G

NICT's Integrated Testbed

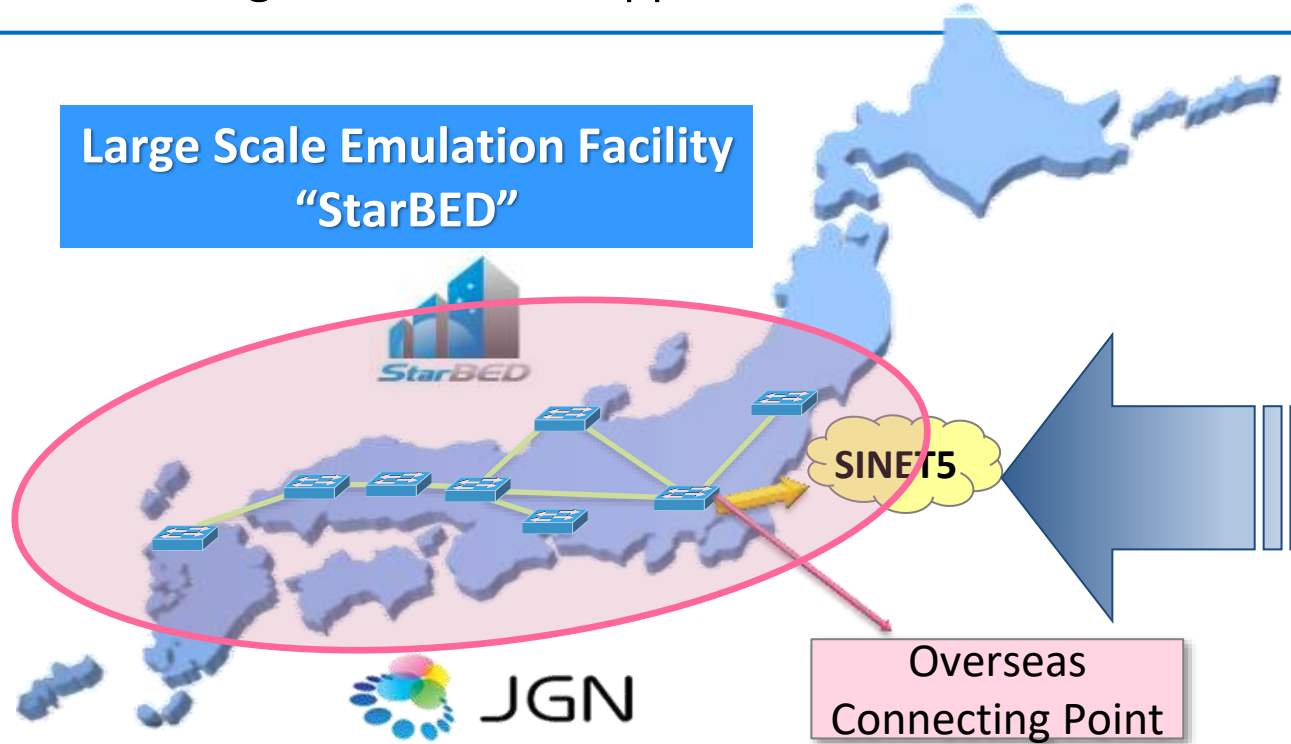## Testbed: Place for field trials of *new* technologies

Contract for R&D purpose

Unit for accelerating technical demo and actual proof in society

- Integrating NICT's testbeds on JGN infrastructure
- Activating testbed use & apps

- Establishing new testbed infrastructure techs
- Cooperation with both outside and inside NICT

Large Scale Emulation Facility "StarBED"

StarBED

SINET5

JGN

Overseas Connecting Point

Ultra High Speed R&D Network Testbed "JGN"

Under design
- **B5G softwarized infrastructure**
- **Data centric cloud service**
- **Reinforcing Emulator for cyber-real fusion**

Additional functions (in service)
- Caravan@ Japan-wide portably
- LPWA @ Yokosuka
- IoT Gateways
- P4 testbed @ 5 sites
- AI-data testbed

Thailand   China   Singapore   USA

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About JGN
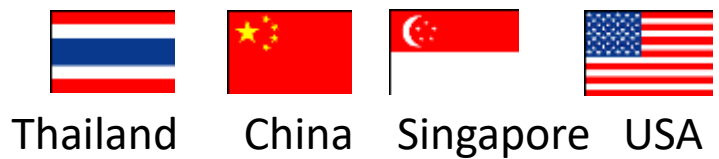
○A *network testbed* operated by NICT

◇JGN started in 1999

○JGN has **international** circuits and **domestic** circuits

◇100 Gbps: Tokyo-Hong Kong-Singapore (*JGN/SingAREN/NSCC*)

◇1 Gbps: Singapore-Bangkok

JGN International Circuits (Oct. 2017-)

Tokyo

Hong Kong

Bangkok

1Gbps

100Gbps (JGN/SingAREN/NSCC)

Singapore

JGN

○JGN supports cutting-edge network experiments

◇High-speed app: uncompressed 8K video transmission

◇Time-sensitive app: next-generation ICT-supported surgery, etc.

○Collaborating with SINET to extend network reachability in Japan

○Collaborating with Asia, Pacific, Oceania, and Europe networks

JGN Global Networks: Connections
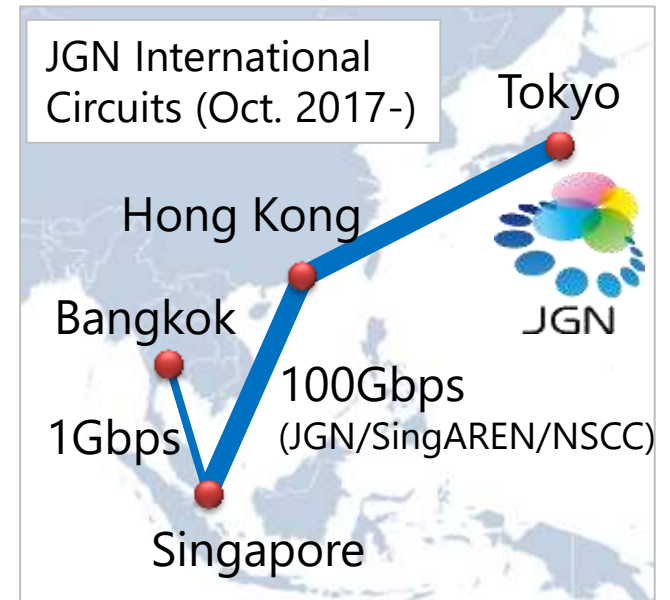
JP-HK line : Tokyo-Hong Kong 100Gbps
HK-SG line : Hong Kong-Singapore 100Gbps
SG-TH line : Singapore-Thailand 1Gbps

AER

100Gbps AsiaPacific-Europe Ring(AER)
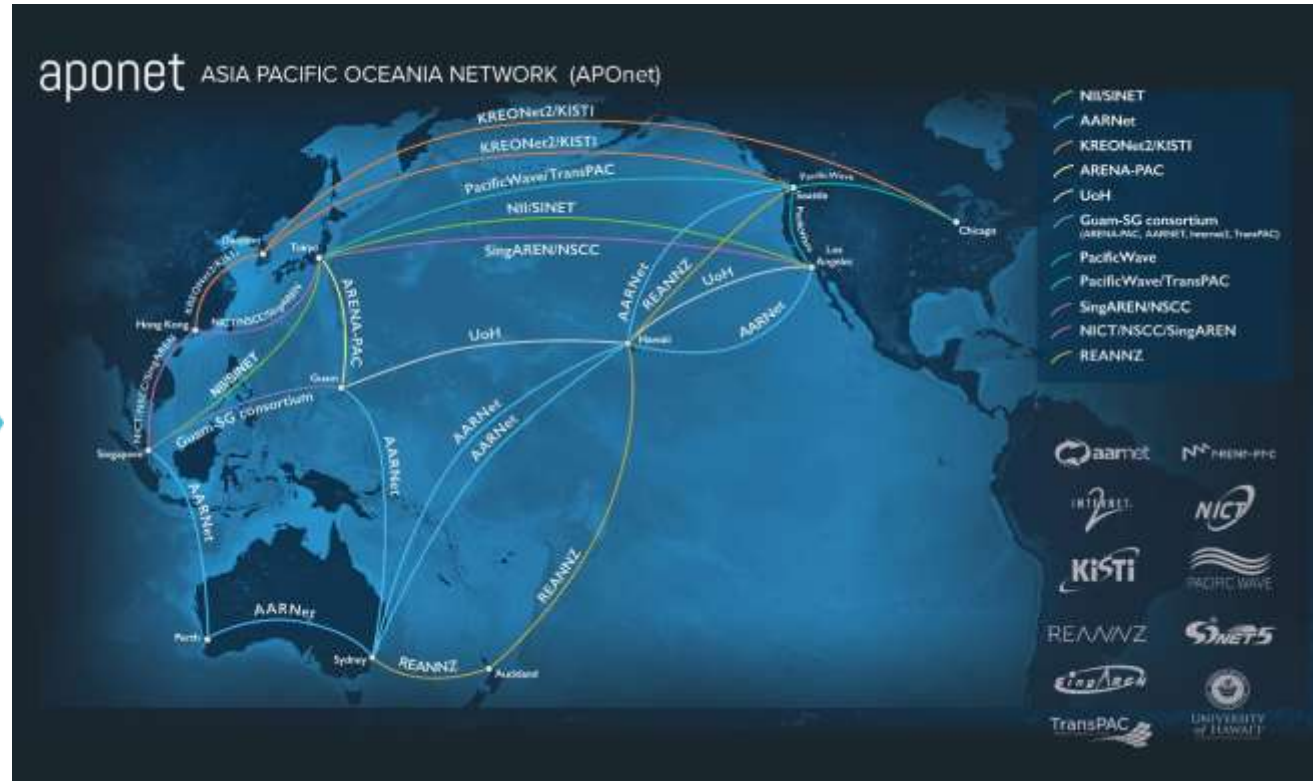
aponet

Asia Pacific Oceania network

June 2021

https://www.aponet.global/

APR: Asia Pacific Ring

2017 年11月～ 現在

WIDE/PW/TransPAC (100G)

SEA

TKO

SINET5(100G)

LAX

JGN/SingAREN(100G)

BKK

HKG

SINET5 (10G)

JGN/SingAREN (100G)

SingAREN/Internet2 (100G)

JGN (1G)

SIN

① TKO-HKG-SIN 10G を 100G に増速(2017年11月)
② Asia Pacific Ring(APR) の形成 (2017年12月)

Dec 2017

aponet ASIA PACIFIC OCEANIA NETWORK (APOnet)

8 collaborations

- Highly available connectivity
- Application development
- Backup traffic
- External experiment
- Cooperation and coordination
- Preferred route identification
- Network research
- Measured data share

11 organizations in
Asia, Pacific, Oceania

JGN Domestic Networks

- A high-speed R&D network infrastructure for ICT technology development
- Designed to provide testing environment for researchers of advanced networking technologies
- Deliver customized services to every user and provide services to multiple projects simultaneously
  - Up to 100 Gbps circuits with L2/L3 connectivity
  - IP virtualization resources (virtual routers, machines, and storages)
  - Optical network testbed

8K monitor

Singapore

8K Camera

4K monitor

8K Camera
4K Camera

Sapporo

IP Multicast
IP Multipath

100Gbps * 2

Tokyo
4K monitor

TransPAC   PACIFIC WAVE

Seattle

Osaka

LA

100Gbps

JGN

Hong Kong

100Gbps

100Gbps

SingAREN

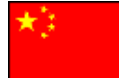INTERNET 2

100Gbps

IP Multicast
IP Multipath

Technical Keypoint of 2018
IP Multicast on Multipaths

Total **51 organizations** joined the demonstration, including Broadcasting Companies, Telecom Carriers, Network equipment manufactures, AV manufactures, Universities, Research Institute, NRENs…

Field trial place for a number of organizations to bring new services, products, equipment, technologies and so on.

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Himawari-8 Realtime Web (Cloud Visualization)

- **Realtime cloud visualization (update 10 min each in Asia-Oceania Area)**
- **Collaborative work between NICT, Japan Meteorological Agency and Chiba Univ.**
- **For disaster prevention**

https://himawari8.nict.go.jp/en/himawari8-image.htm?
https://himawari.asia/

Number of Web page views
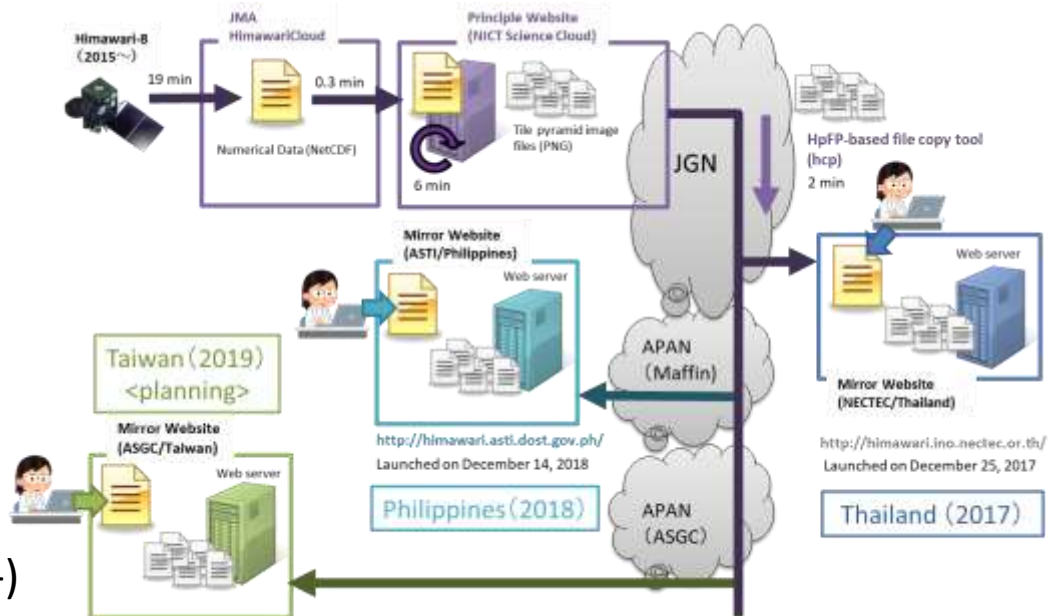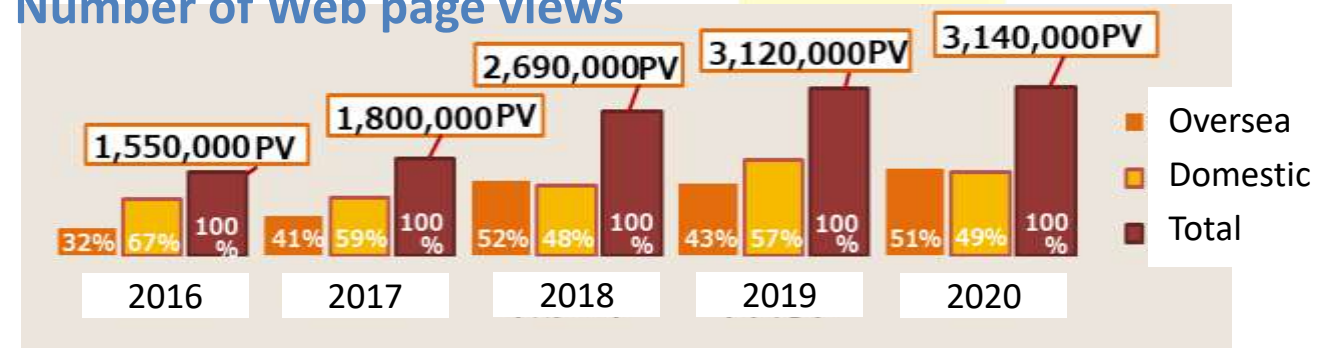
Mirrors to Thailand (2017-),
Philippines (2018-), Taiwan (2019-)

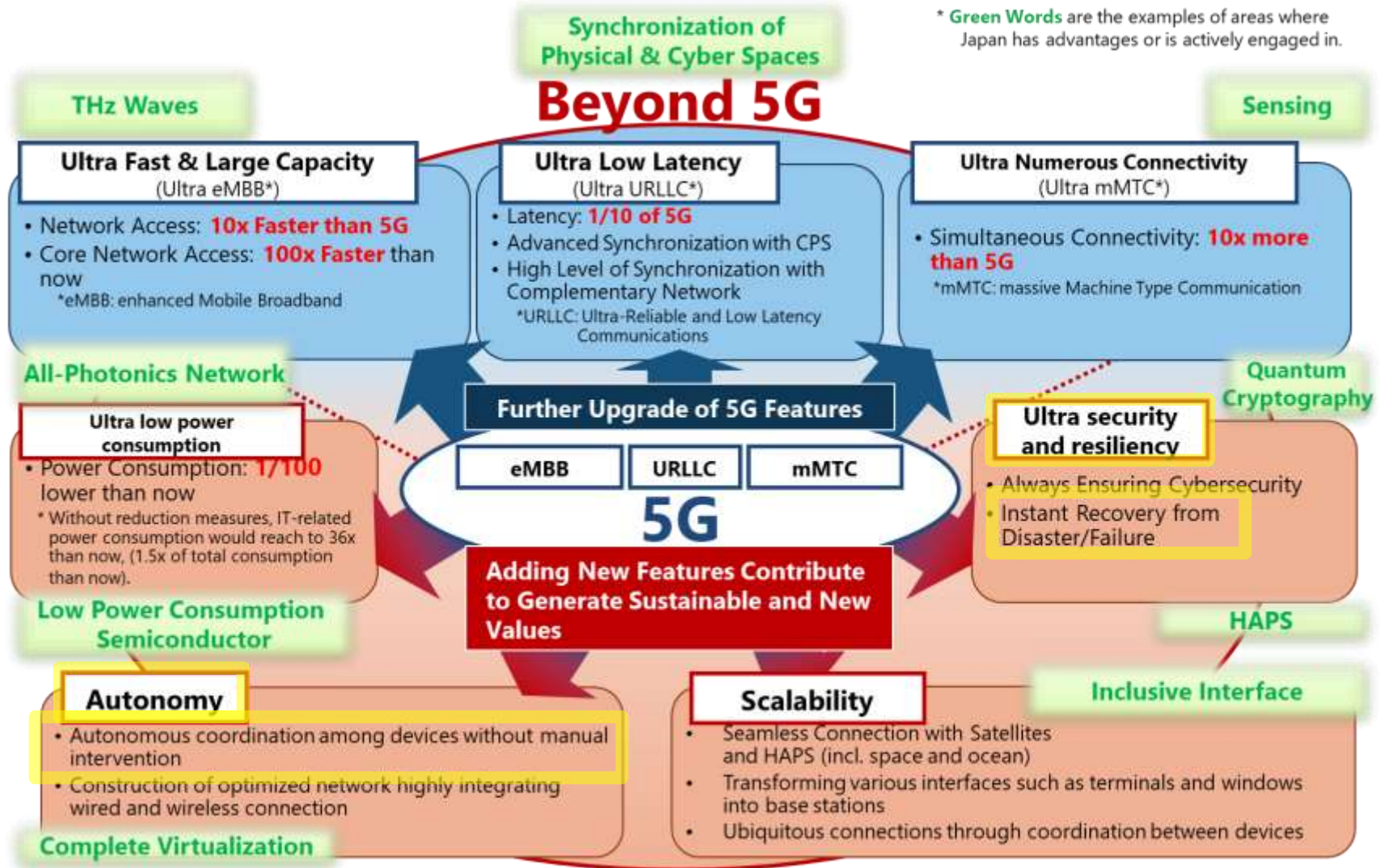- Intercontinental comparison of lattice clocks
- Developed a broadband VLBI system for intercontinental frequency transfer
  - 4 - 6 Gbps Global Data Transfer, 60 TB for 1 session monitoring
  - 8,700 km baseline
- Transportable radio telescopes could provide global high-precision comparisons of the best atomic clocks

https://www.nict.go.jp/en/press/2020/10/08-1.html
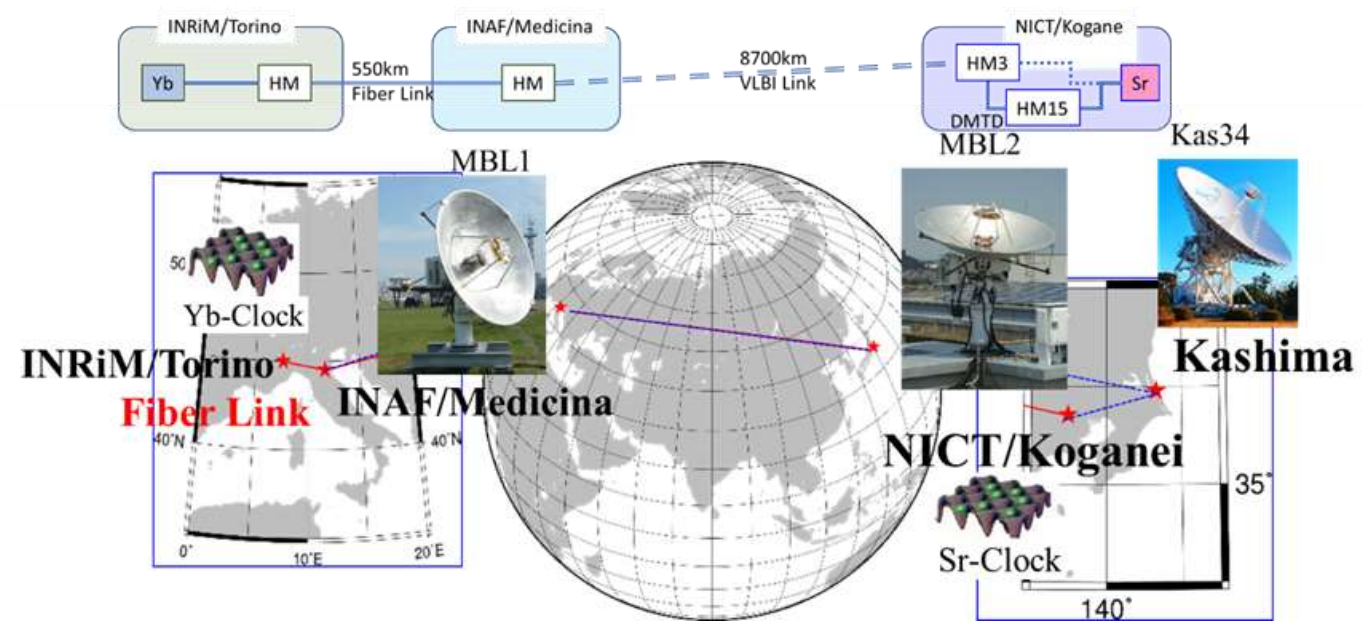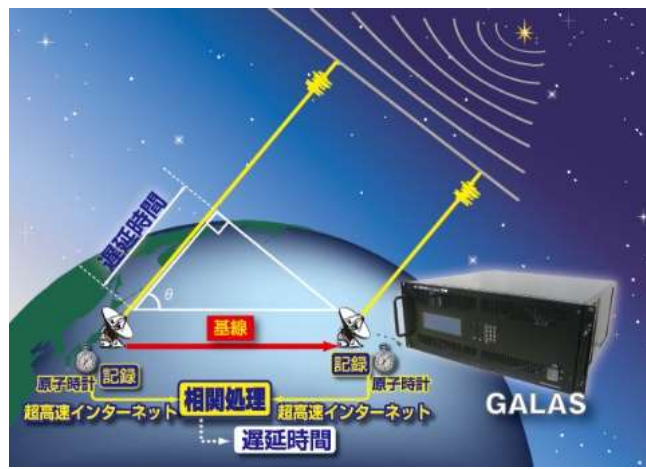
Next Step

(Will be ready in 2022)

Beyond 5G Requirement

Strategy Outline of Beyond 5G Promotion-Roadmap to 6G - MIC

Source:
Beyond 5G Promotion Consortium https://b5g.jp/en/
Beyond 5G Promotion Strategy - Roadmap to 6G - , MIC (2020)

Technology Requirement to Network Testbed

(Post) Cloud Native

- Cloud friendliness, OSS platform, softwarization, programmability

Mobile Communication

- B5G/6G, mobile core, RAN, local 5G

Optical Communication (Raw Fiber)

- Ultrafast optical commun., multi-core fibers, quantum commun., optical lattice clock

Testbed Fundamental Functions

- Monitoring, debugging, reproducibility

Testbed Common Platform

- Openness, PPP test-site, standardization

(Cf) a WG Paper, Testbed Subcommittee, Smart IoT Acceleration Forum

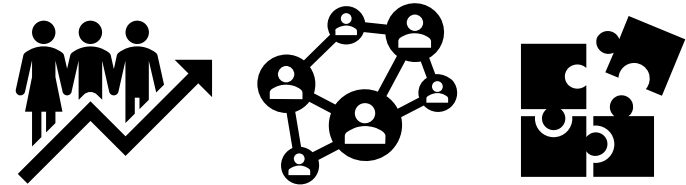# Toward Network Testbed to Making Beyond 5G

| Raising Community Level | Cutting-Edge Net R&D | Openness & Standard |

Testbed as an innovation eco-system hub

Human and Tech Development
- Raising level of community
- Personnel exchange, training / circulation
- Technology utilization, evolution & deployment

Induction of demonstration experiments by companies

- Sustainable evolution of network and service infrastructure towards beyond 5G
  - Cooperation with telecom, datacom and their vendors
- Provide open places as **innovation eco-system hub**
- Activate community such as industry collaboration and university involvement
- Build a system that allows developments to be used **within the community and returns the results to the development side**
- Expand functions required to induce social implementation

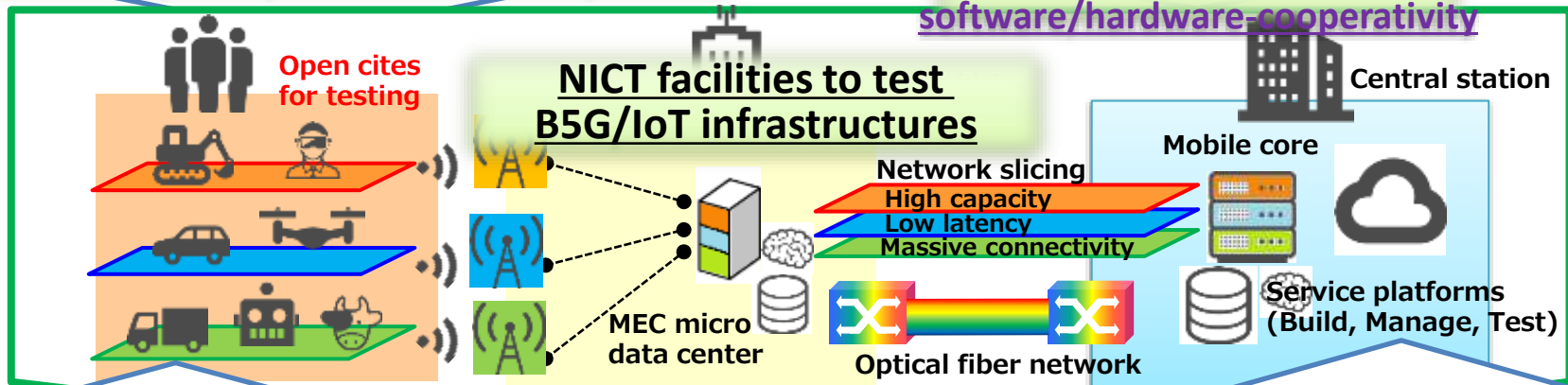# B5G/IoT Testbeds with High-reliability and High-elasticity

NICT is promoting **B5G/IoT Testbed** concepts that enable tests and evaluations on the highly advanced communication networks with **high-reliability and high-elasticity** in B5G/6G era by concentrating the diversified technologies via the industry-academia-government collaborations.

Evaluations on expandability, interoperability, and automatability for open and software systems
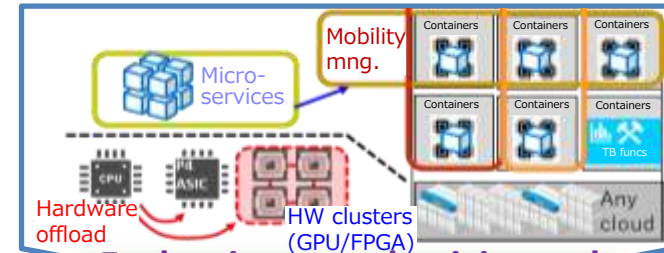
Evaluations on elasticity and software/hardware-cooperativity

Open cites for testing

NICT facilities to test B5G/IoT infrastructures

Central station

Mobile core

Network slicing
High capacity
Low latency
Massive connectivity

MEC micro data center

Optical fiber network

Service platforms (Build, Manage, Test)

Developments of humans and technologies

Testbed utilizations by various organizations to accelerate R&D and PoC

Elasticity and reliability tests on optical systems and slicing systems

- Expanded social networks
- Personnel exchanges
- Enhanced technology transfer

PoC promotions by industries

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Co-creation of B5G/IoT Testbed
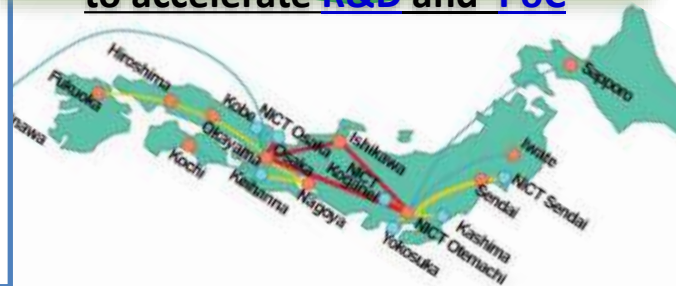
Extendible Framework
- Nets and edge slicing
- Sustainable evolution
- Open source software
- Build with open technologies

Evolution to Beyond 5G
- High elasticity = elastic slicing
- Low latency = soft- & hardware
- Autonomy = Automation level 4
- Call for new service experiments

Build and evolve co-creation testbed
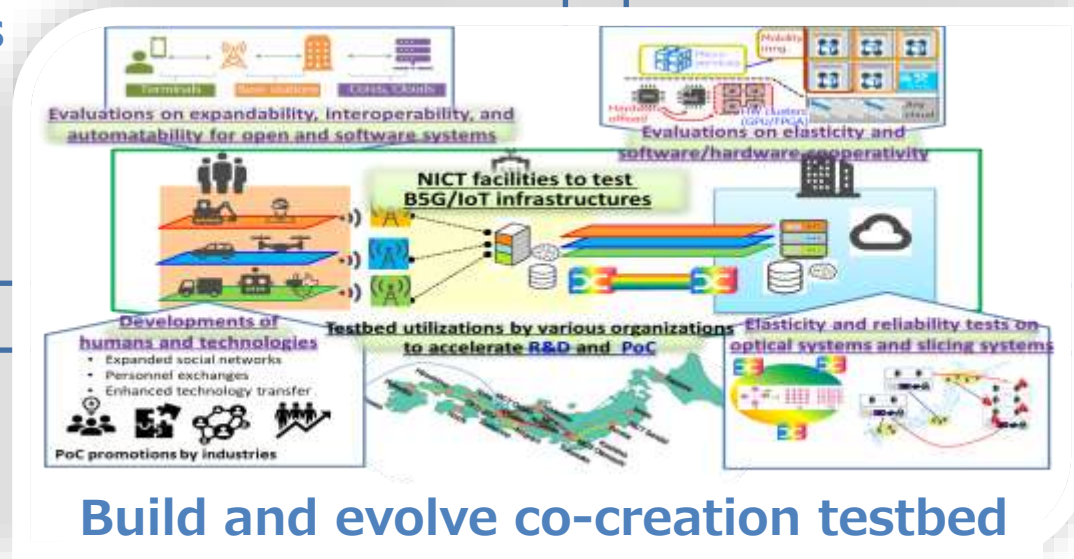
Building a collaboration hub
- OSS and white-boxes
- collaboration · co-creation · competition
- (real hub after COVID-19)

Evolvable ecosystem
- Infrastructure trials with real service prototypes
- Pilot service trials on instable but latest infra
- Success to practical use

ICT Testbeds toward B5G/6G Era

- **Building and Evolving Testbeds for verifying social and technical needs in Beyond 5G era**
- **Creating values, Contributing to solving social issues & Creating ICT service ecosystem thru' the Testbed**

Contributing to R&D, Technology Verification, Social Implementation and International Collaboration in ICT Field

- Supporting the demonstration environment of world cutting-edge technologies such as optical and quantum communication technologies

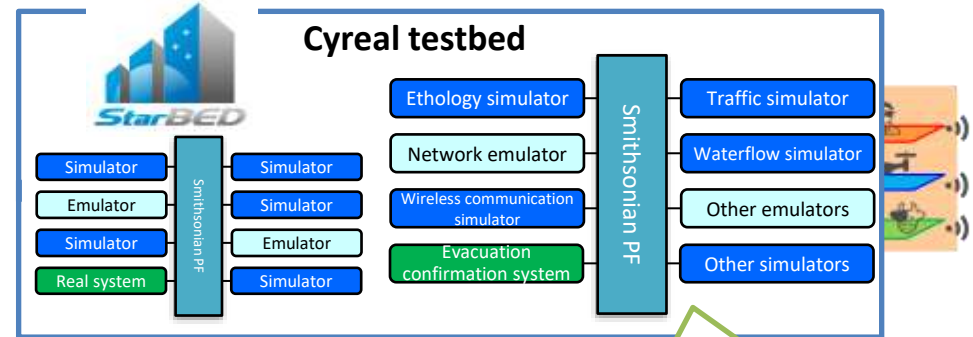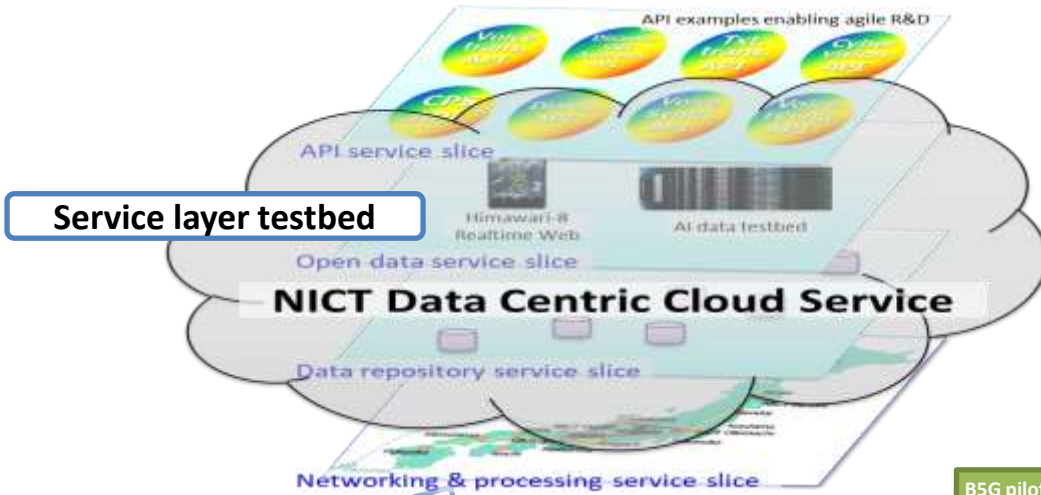## Contributing to the Creation of New Value and the Solution of Social Issues

- Rally the R&D capabilities of testbed users (NICT, research institutions, telecommunications carriers, vendors and ventures) into the testbed through forum activities and national projects

Promoting Efforts to Create an Internationally Attractive R&D Hub

- Evolution of the testbed environment through the DevOps

Summary of NICT's Testbed Direction for Beyond 5G/IoT

New testbed structure by combining Service Layer Testbed and Softwarized Infrastructure Testbed (ex. edge-cloud platform)
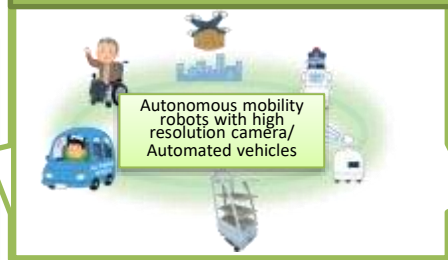
- API cooperated cloud service
  - Creating new values via data coordination
- B5G softwarized infrastructure
  - Adding mobile, elasticity, and reliability
  - Making real B5G evolutionarily
- Emulator enabling cyber-real fusion
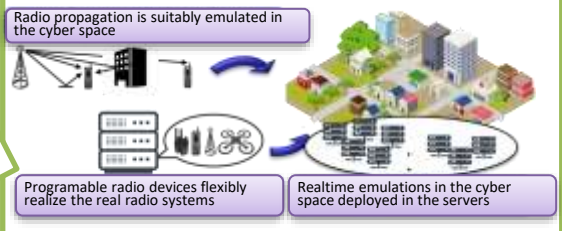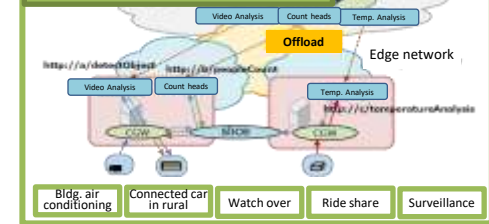 - facilitating simulation linkage and new tech add-on

Service layer testbed

API examples enabling agile R&D

API service slice

Himawari-8 Realtime Web

AI data testbed

Open data service slice

NICT Data Centric Cloud Service

Data repository service slice

Networking & processing service slice

Cyreal testbed

StarBED

Simulator		Simulator
Emulator	Smithsonian PF	Simulator
Simulator		Emulator
Real system		Simulator

Ethology simulator — Traffic simulator

Network emulator — Waterflow simulator

Wireless communication simulator — Other emulators

Evacuation confirmation system — Other simulators

Smithsonian PF

B5G softwarized infrastructure testbed

Internet

Cloud

Other TBs

Oversea Nets

JGN

Pilot test for the edge computing

Video Analysis | Count heads | Temp. Analysis

Offload

Edge network

Video Analysis | Count heads | Temp. Analysis

CGW | SBOE | CGW

Bldg. air conditioning | Connected car in rural | Watch over | Ride share | Surveillance

B5G pilot test for socially acceptable ICT services

Autonomous mobility robots with high resolution camera/ Automated vehicles

Wireless emulator

Radio propagation is suitably emulated in the cyber space

Programable radio devices flexibly realize the real radio systems

Realtime emulations in the cyber space deployed in the servers

Summary of R&D

- **Development of testbed technologies**
- **Pilot test for the edge computing**
- **B5G pilot test for a socially acceptable ICT services**
- **Pilot test of Cyreal collaboration; Contribution to the wireless emulations**

Visions on construction:

- Assumed expansions in functionalities
- Suitably distributed function blocks

Visions on management:

- Opened testbed to technologies carried from outside
- Flexible expansions and modifications via software updates and softwarization
- Suitable management layer
- Assumed synergies among different technologies

Visions on promotion:

- Promotion forums/consortiums to create further advanced utilizations

- We contribute to making the future thru' the testbed
- Testbed as an innovation eco-system hub

Thank you!