NICT's Integrated Testbed

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ICT Testbed Research and Development Promotion Center

National Institute of **I**nformation of **C**ommunications **T**echnology

NICT Organization

NICT
National Institute of Information and Communications Technology

Public Services
- Japan Standard Time
- Space Weather Forecast
- Wireless Equipment Testing &Calibration ...

1. Strategic R&D
2. Open Innovation
3. Global Deplayment

The Solo National Research Institute in the field of ICT in JAPAN.

- ICT for Sustainable World and Human Happiness
- Promoting its own research and development
- Cooperating with and supporting industry and academia
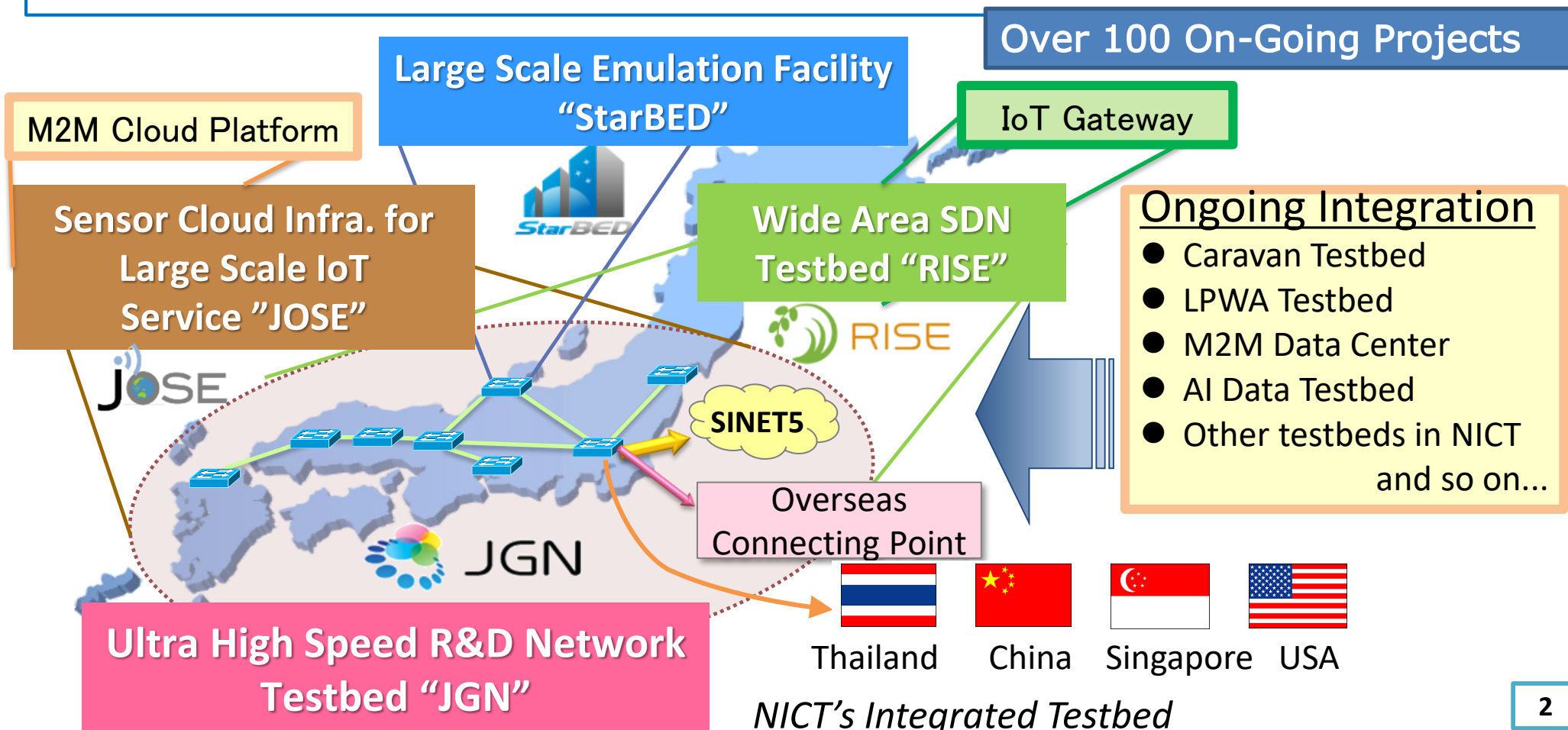
Industry/Academia/Government Innovation Platform

NICT's Integrated Testbed

Testbed: Place for field trials of *new* technologies

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 inside and outside NICT
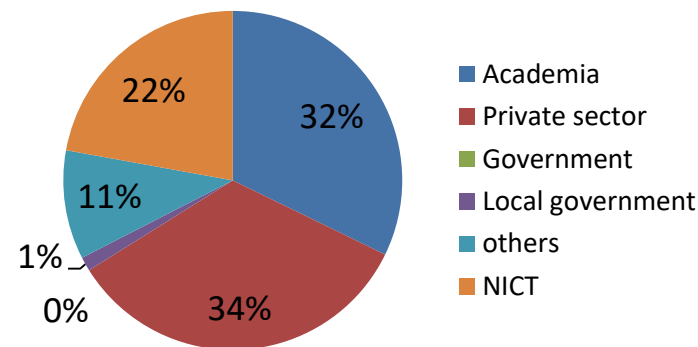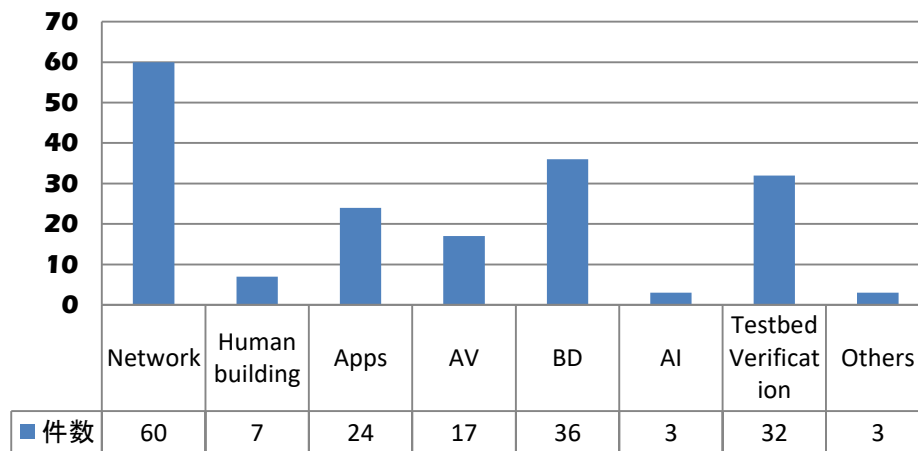
Over 100 On-Going Projects

M2M Cloud Platform

Large Scale Emulation Facility "StarBED"

IoT Gateway

Sensor Cloud Infra. for Large Scale IoT Service "JOSE"

Wide Area SDN Testbed "RISE"

StarBED

JOSE

RISE

SINET5

Ongoing Integration
- Caravan Testbed
- LPWA Testbed
- M2M Data Center
- AI Data Testbed
- Other testbeds in NICT and so on...

JGN

Overseas Connecting Point

Ultra High Speed R&D Network Testbed "JGN"

Thailand   China   Singapore   USA

NICT's Integrated Testbed

Activities

<FY 2016 - FY2017>

Projects available at (in Japanese)
https://testbed.nict.go.jp/example.html

148 件
RESEARCH PROJECT

318 Organizations
（cumulative total）

Organization (FY2017)

- Academia — 32%
- Private sector — 34%
- Government — 0%
- Local government — 1%
- others — 11%
- NICT — 22%

Number of items by field (FY 2017)

|	Network	Human building	Apps	AV	BD	AI	Testbed Verification	Others
■件数	60	7	24	17	36	3	32	3

About JGN

- A *network testbed* operated by NICT
  - JGN started in 1999

- JGN has **international** circuits and **domestic** circuits
  - 100Gbps: Tokyo-Hong Kong-Singapore (*JGN/SingAREN/NSCC*)
  - 1Gbps: 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.

- We have been collaborating with SINET to extend network reachability in Japan
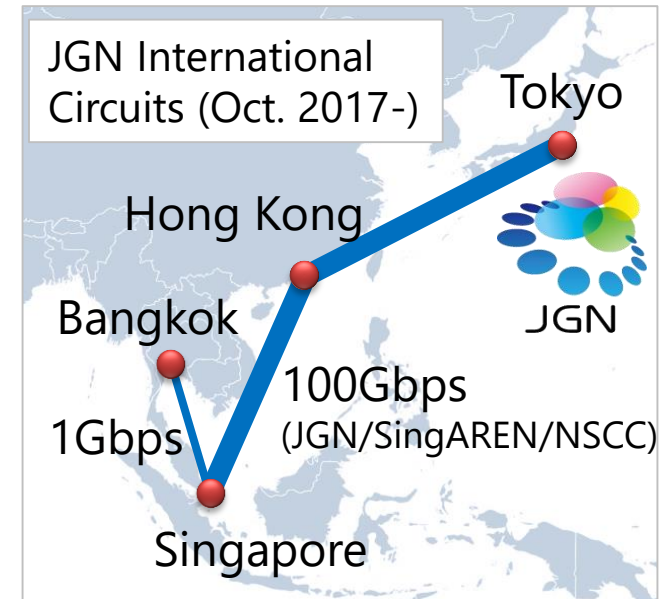
100Gbps Asia-Pacific Ring (APR)
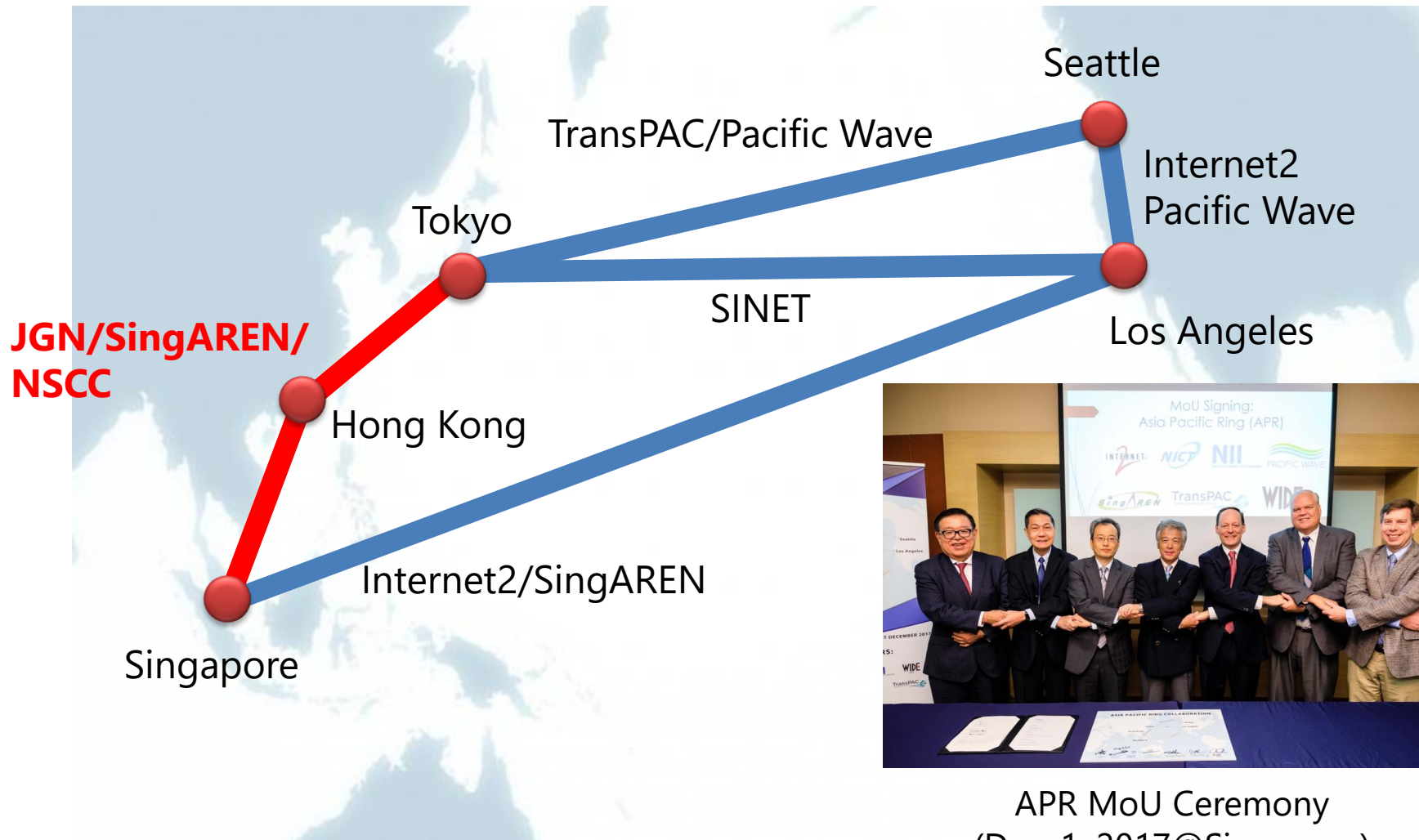
APR MoU Ceremony
(Dec. 1, 2017@Singapore)

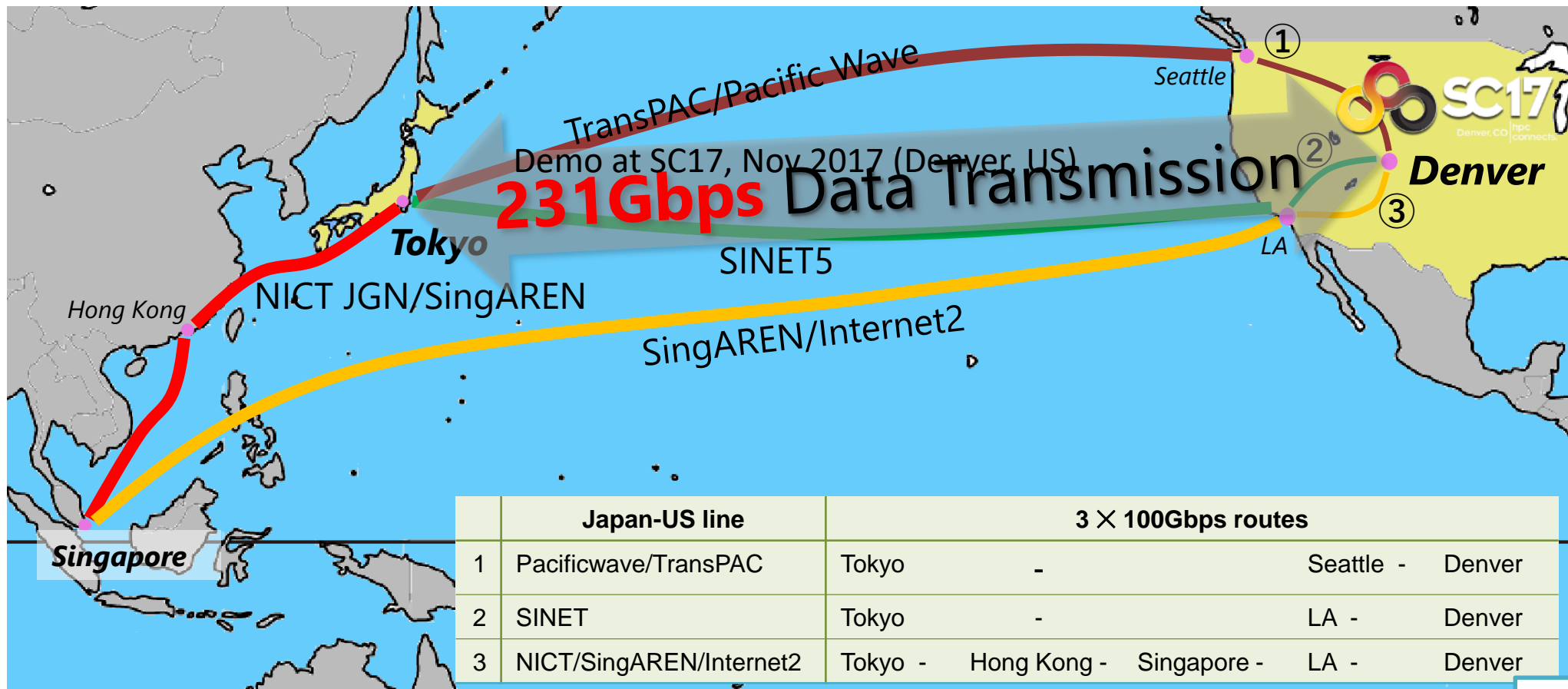# Super-High-Speed Long Distance Data Transmission at SC17 (2017 Nov.)

231 Gbps data transmission over three 100 Gbps routes

- Using NII's MMCFTP (Massively Multi-Connection FTP) protocol

Demo at SC17 (Denver, US)

	Japan-US line	3 × 100Gbps routes				
1	Pacificwave/TransPAC	Tokyo	-			Seattle - Denver
2	SINET	Tokyo	-			LA - Denver
3	NICT/SingAREN/Internet2	Tokyo -	Hong Kong -	Singapore -		LA - Denver

Uncompressed 8K Video Transmission at Sapporo Snow Festival (2018 Feb.)

8K monitor

8K Camera

4K Camera

Sapporo

IP Multicast
IP Multipath

100Gbps * 2

TransPAC
AMERICA CONNECTS TO ASIA

PACIFIC WAVE

Tokyo

4K monitor

Seattle

Osaka

LA

100Gbps
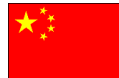
100Gbps

JGN

Singapore

8K Camera

Hong Kong

100Gbps

INTERNET
2

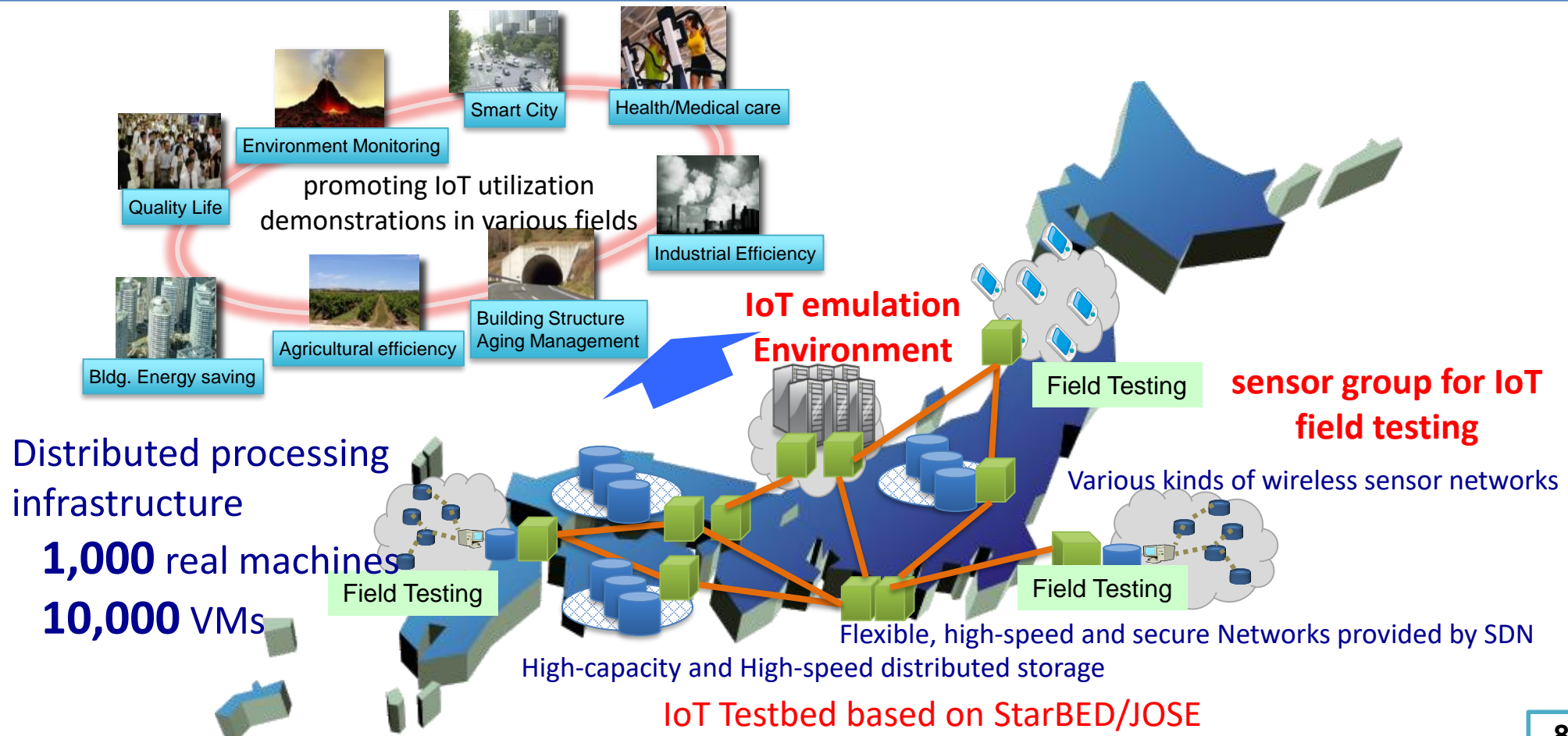SingAREN

4K monitor

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.
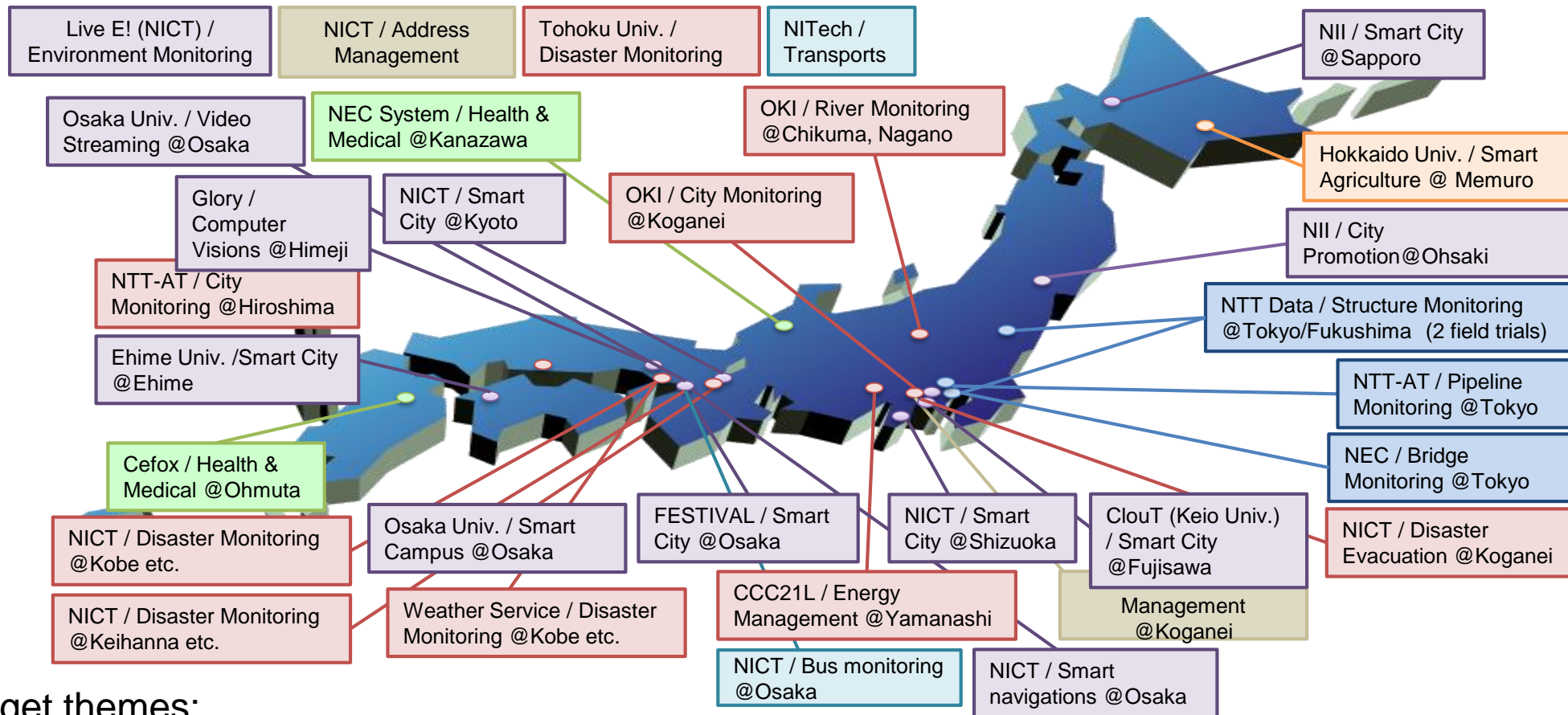
Testbeds (JOSE/StarBED) for IoT

- IoT Verification Testbed
  - Information processing infrastructure
  - Real time processing and analyzing of data obtained from a large amount of sensors
- Contribution for the new business creation by
  - Promoting the technical and social demonstration utilizing IoT in various fields

Environment Monitoring

Smart City

Health/Medical care

Quality Life

promoting IoT utilization demonstrations in various fields

Industrial Efficiency

Bldg. Energy saving

Agricultural efficiency

Building Structure Aging Management

IoT emulation Environment

Field Testing

sensor group for IoT field testing

Various kinds of wireless sensor networks

Distributed processing infrastructure

1,000 real machines

10,000 VMs

Field Testing

Field Testing

Flexible, high-speed and secure Networks provided by SDN

High-capacity and High-speed distributed storage

IoT Testbed based on StarBED/JOSE

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Field Trials on JOSE since 2012

Contribution for R&D Community, accelerating service deployment of IoT technology through 33 field trial projects in 7 Target themes

- Live E! (NICT) / Environment Monitoring
- NICT / Address Management
- Tohoku Univ. / Disaster Monitoring
- NITech / Transports
- NII / Smart City @Sapporo
- Osaka Univ. / Video Streaming @Osaka
- NEC System / Health & Medical @Kanazawa
- OKI / River Monitoring @Chikuma, Nagano
- Hokkaido Univ. / Smart Agriculture @ Memuro
- Glory / Computer Visions @Himeji
- NICT / Smart City @Kyoto
- OKI / City Monitoring @Koganei
- NII / City Promotion@Ohsaki
- NTT-AT / City Monitoring @Hiroshima
- NTT Data / Structure Monitoring @Tokyo/Fukushima (2 field trials)
- Ehime Univ. /Smart City @Ehime
- NTT-AT / Pipeline Monitoring @Tokyo
- NEC / Bridge Monitoring @Tokyo
- Cefox / Health & Medical @Ohmuta
- FESTIVAL / Smart City @Osaka
- NICT / Smart City @Shizuoka
- ClouT (Keio Univ.) / Smart City @Fujisawa
- NICT / Disaster Evacuation @Koganei
- NICT / Disaster Monitoring @Kobe etc.
- Osaka Univ. / Smart Campus @Osaka
- NICT / Disaster Monitoring @Keihanna etc.
- Weather Service / Disaster Monitoring @Kobe etc.
- CCC21L / Energy Management @Yamanashi
- Management @Koganei
- NICT / Bus monitoring @Osaka
- NICT / Smart navigations @Osaka

Target themes:

| Smart City : 14 | Disaster Monitoring : 8 | Infrastructure : 4 | Agriculture : 1 |
| Health & Medical : 2 | Transports : 2 | Network Management: 2 | |

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StarBED in Ishikawa

A cluster of 1000 or more PCs dedicated to diverse huge-scale verifications

- Realtime emulation
- Common OS and software work
- Hardware-as-a-Service (OS can be replaced for user's purpose)
- Can bring-your-own hardware
- Can make arbitral network topology
- Can allow "ERROR" by separation from Internet
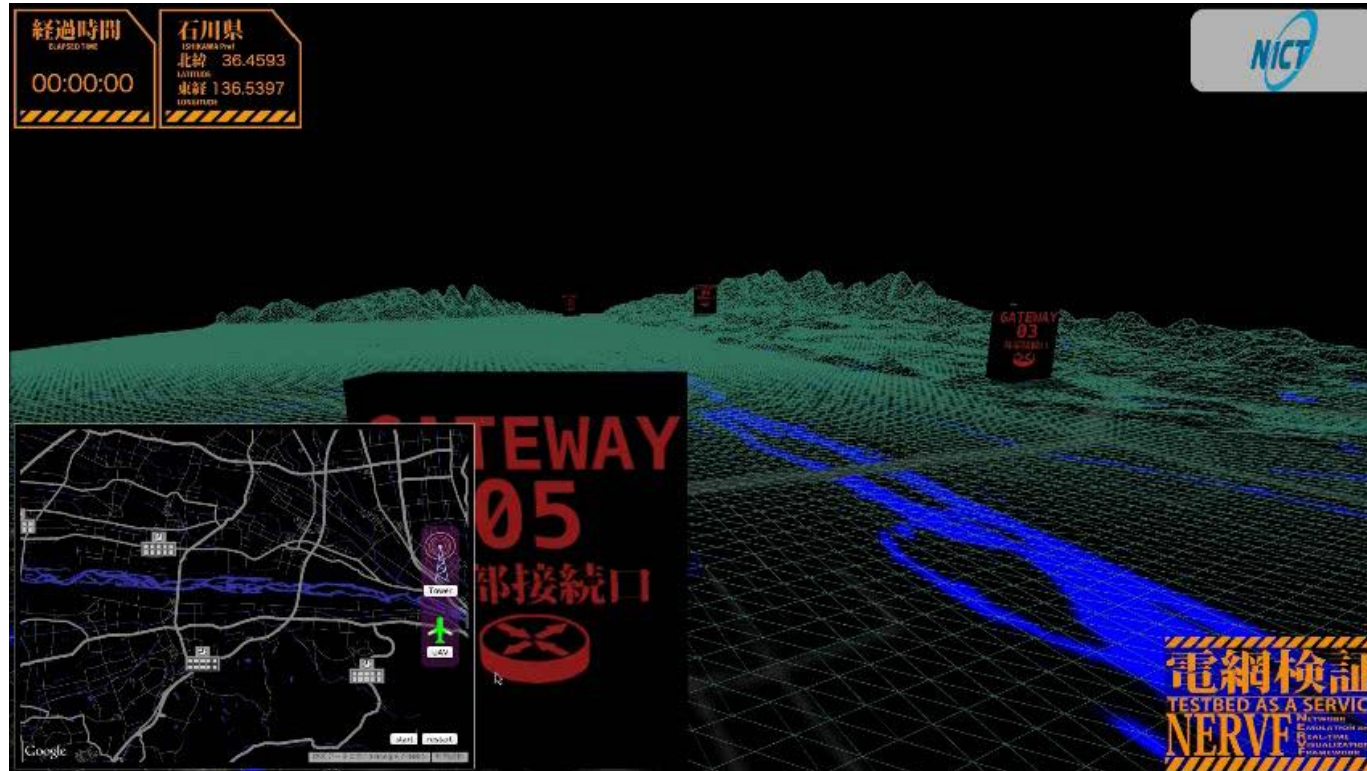- Can verify behavior of malware in isolated environment

Designing ICT Infrastructure with *Emulation on StarBED*

Problems in traditional approaches for large-scale ICT infra designi

- Simulations: **poor accuracy of the results**
- Field trials with real systems: **high cost and poor scalability**

➡️ *Emulation* is the key to the effective solution

Case study on StarBED: **Multi-hop wireless communications emulator** on StarBED
- ✓ **Real landscape data** is loaded from GIS (geographic information system).
- ✓ **Full-stack communication software** of every object is run on StarBED.
- ✓ Users can place and move **any objects** (Unmanned Aerial Vehicles, Antennas) **anytime, anyw**

Cooperating with Smart IoT Promotion Forum

- **Caravan Testbed: Portable wireless communication apparatus**
- ■Portable system stand-by, up to 3 months dedicated use for IoT environment
  - A variety of sensing devices (e.g. temperature , vibration)
  - Communication devices (WiFi/ LPWA / LTE)
  - A portable server & edge node
  - Emergency power supply & High capacity battery

→**Portable wireless communication apparatus set for IoT's first/last 1 mile**

- **LPWA Testbed: Verification Field with Multiple LPWAs**

■ Support LPWA-base IoT Promotion thru' LPWA survey and verification field deployment

→**We are promoting a framework of cooperation, including the local government and industry, centering on the Yokosuka Telecom Research Park.**

IoT Caravan System Testbed: Available Equipment

SmartSight camera

LPWA Test machines

NerveNet (WiFi、LPWA)

sensors

IoT-GW (LTE)

Core network (JGN・RISE)
Cloud platform (JOSE)

Emulation platform (StarBED)
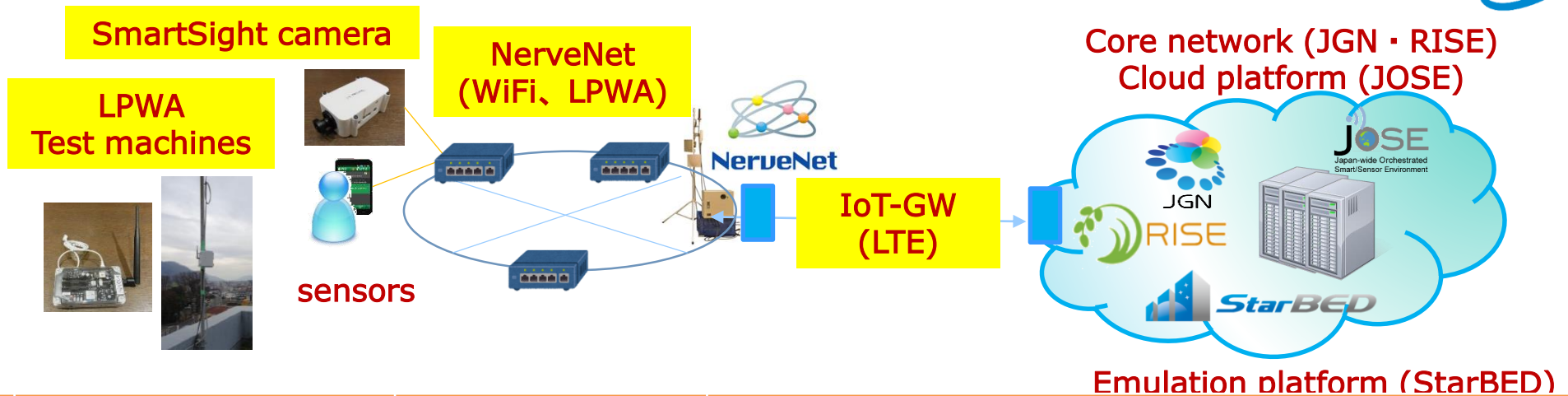
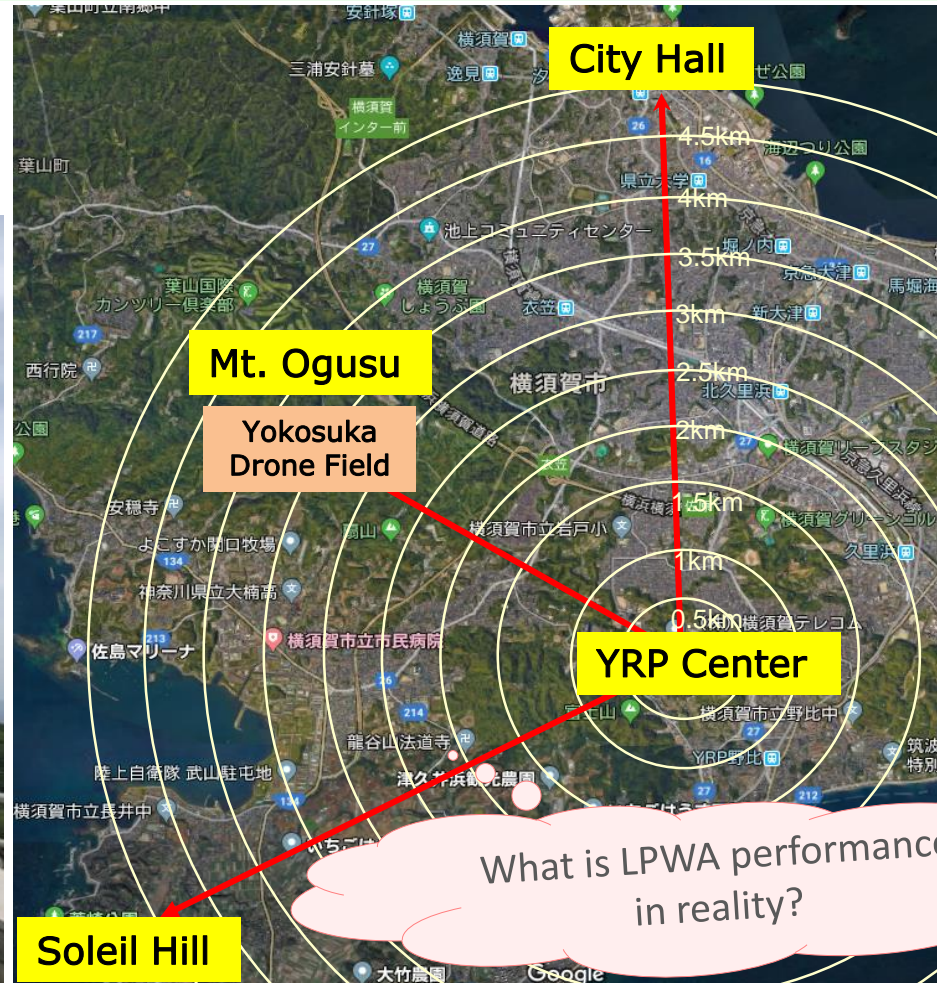|	Requests	Used facilities	Functions
1	Want to connect easy & secure LTE line to the NICT's core network	IoT Gateway	• Secured connection the core network • No need complicated gateway configuration (NICT does) • Possible wired/WiFi selection for device commun.
2	Want communication lines at no infrastructure place	NerveNet	• A distributed network that uses wireless (WiFi, LPWA) multi-hop technology can be constructed in place without a communication infrastructure • Support power supply (buttery & solar panels)
3	Want trial of LPWA at favorite and arbitral places	LPWA (LoRa) test machines	• LPWA commun. map is easily created by reporting LPWA commun. possibility from a GPS-aware child machine to a BS at each measurement point
4	Want verifying video	SmartSight	• Transmission of the image itself and

LPWA Testbed: Verification Field with Multiple LPWAs

- **Yokosuka Hybrid LPWA Testbed** launched by Yokosuka Telecom Research Park
- **Experiment multiple LPWA (**as of Oct 2018, **Sigfox, LoRa, Wi-SUN) on the same c**
  - **Rent LPWA base stations and LPWA devices**
  - **Use users' own LPWA devices**
- ⇒ **Pilot operation (free) from August 2018** （http://www.yrp.co.jp/LPWA/index.htm

Rooftop,
YRP Center

City Hall

Rooftop,
Yokosuka City Hall

Mt. Ogusu

Yokosuka
Drone Field

YRP Center

Soleil Hill

What is LPWA performance in reality?

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- We support transnational science thru' our integrated testbed with "**High-speed** and **IoT**" "**Network** & **Distributed Cloud**"
  - 100 Gbps Nation-wide & Asian circuits
  - IoT aware verification environment
  - Large-scale sensor/could infrastructure
  - Large-scale emulator

Thank you!

NICT will continue to contribute to the International community.
www.nict.go.jp

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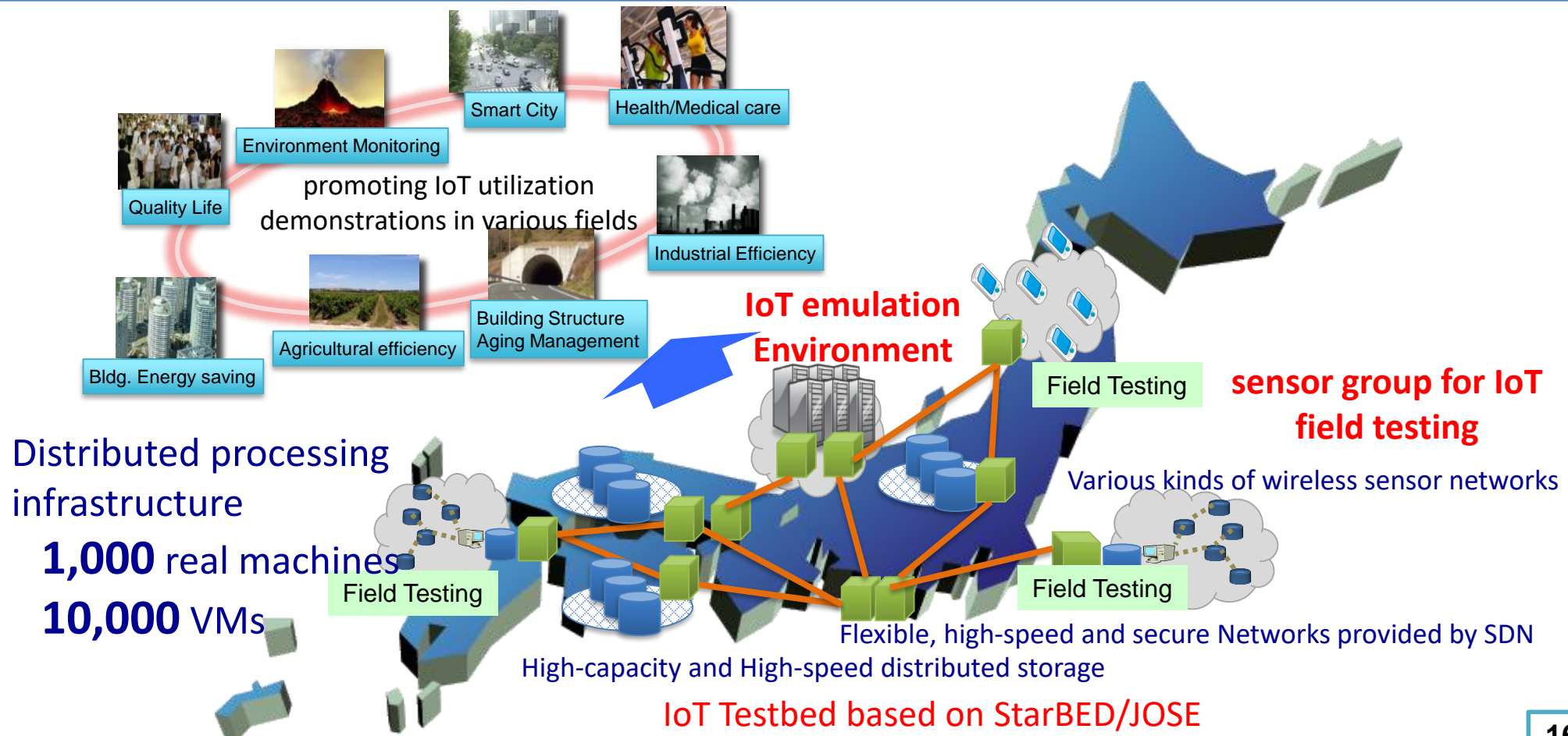
- **Increased** devices, functions and data
- **Diversified** extreme service Reqs.
- **Reduced** working-age population
- **Keep** CAPEX/OPEX

- In-vehicle image sensor: 1 million cars x 20 Mbps = 20 Tbps
- Auto driving: < 2 msec response
- AR: < 16 msec response

- **Automatically** managing virtualized Nets & IoT edge computing environment
- **Elastically & agilely expand** computing & net resources in respond to scene change of event
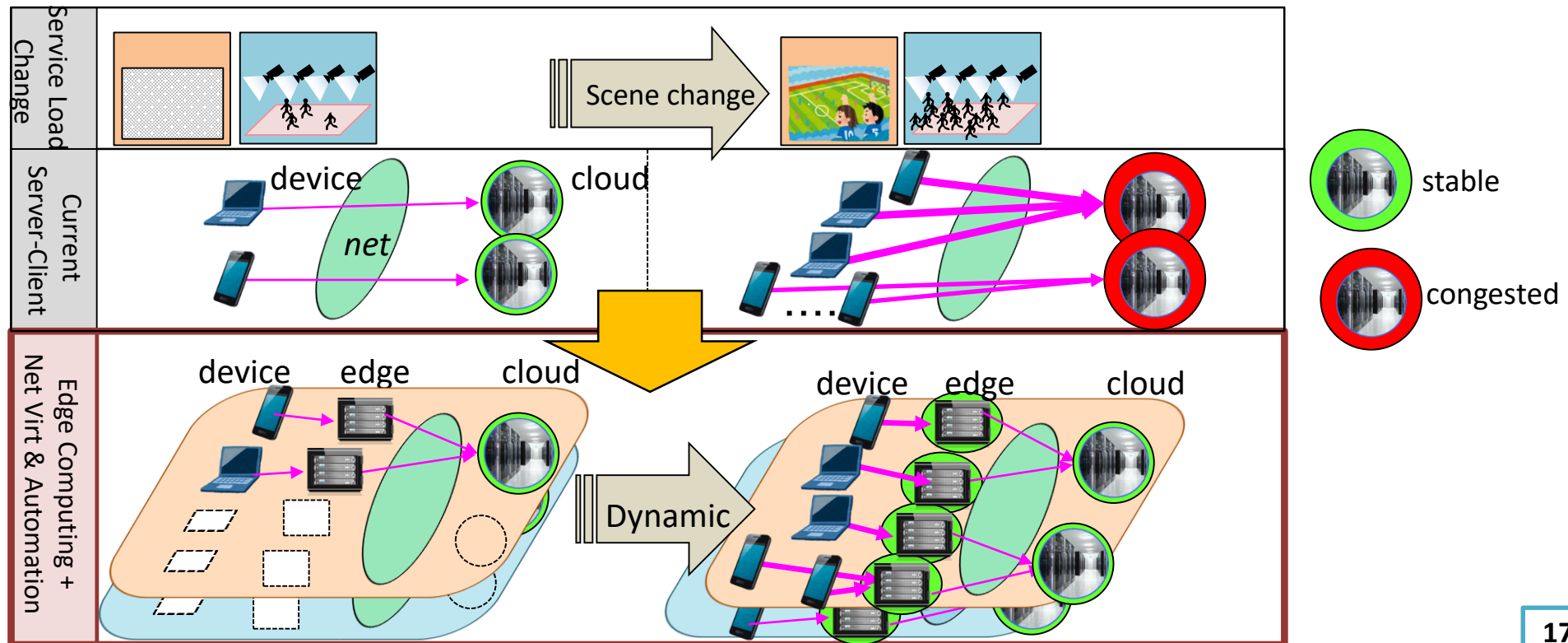
Testbed Partners

- **Coordinate NICT's testbed and partners' hardware, software, services and ot**
- **Promoting the further testbed utilization**

Impact

- NICT: The partnership can expand the NICT Testbed, allowing users in various fields to take advantage of the capabilities of a more diverse and evolving NICT's Testbed.
- Partners: The products such as hardware and/or software provided by the partners can be improved their visibility, quality of services and customer satisfaction through the use of the products on NICT's Testbed.
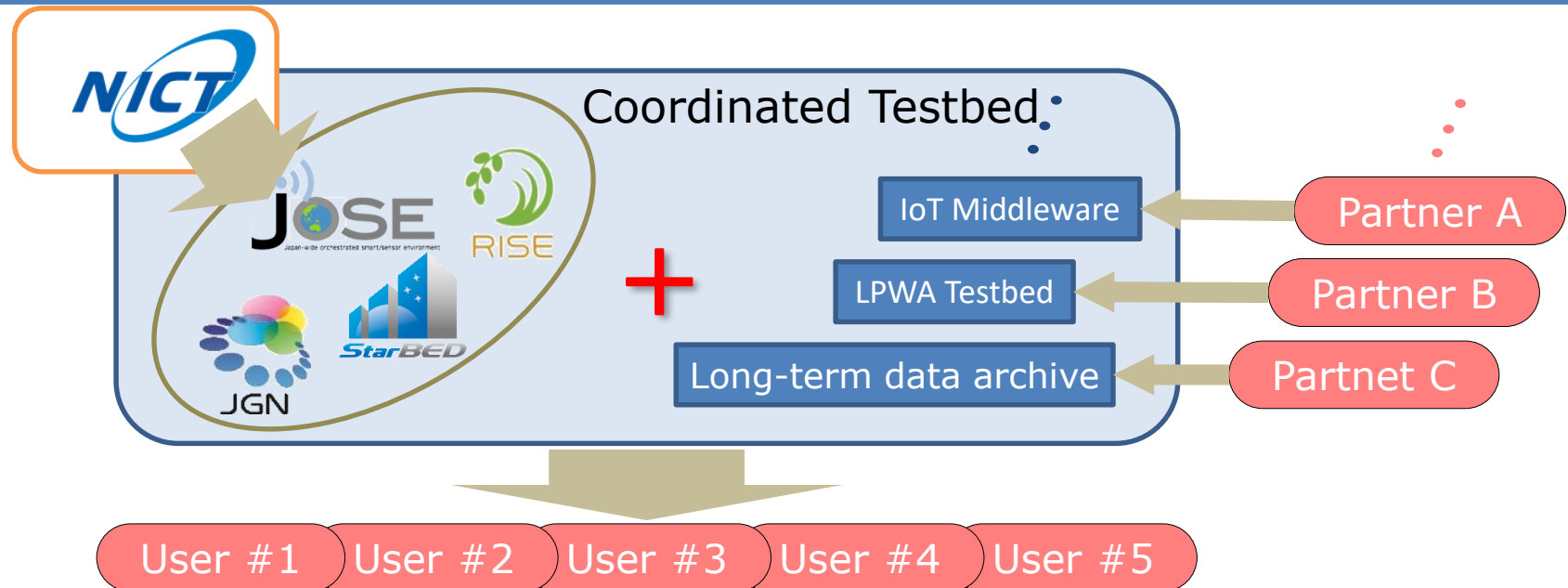
IoT Caravan System Testbed

- Portable wireless communication apparatus set for IoT's first/last 1 mile
- Prepare a set of portable systems to create an IoT testbed environment for up to 3 months per project.
  - Promote demonstration experiments in which multiple functions of JGN/RISE/JOSE/StarBED, sensor devices and communication devices are combined
  - Solicit IoT verification

A new initiative reflecting the examination of Testbed Subcommittee in the Smart IoT Promotion Forum.

Caravan Testbed

Remark: No car in real
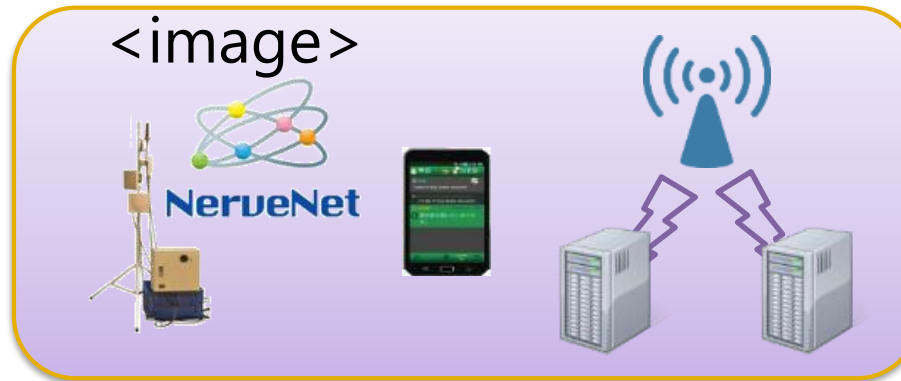
- Diverse sensing devices (temperature, vibration）
- Communication devices （WiFi/ LPWA / LTE）
- Portable servers ● Edge nodes
- Emergency power supply ● Large-volume battery

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Case Study: Improving Open Source Software

Testbed accelerates deployment of OSS into commercial infrastructure though supporting verification of its scalability, performance, stability, operations, etc.

Raising operation of OpenStack Neutron to commercial operation level

16Gbps communications throughput among servers with VXLAN off-loading
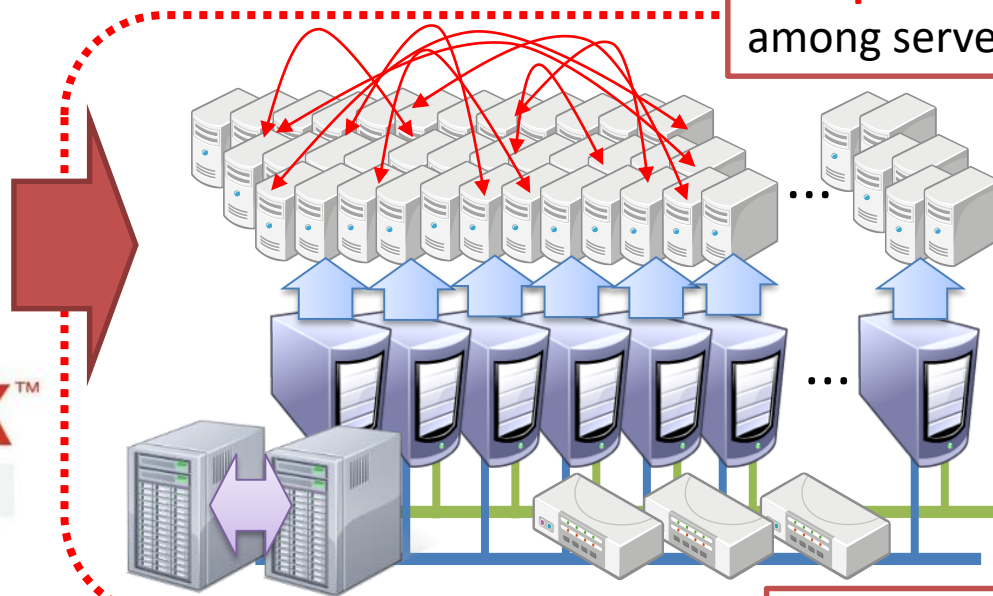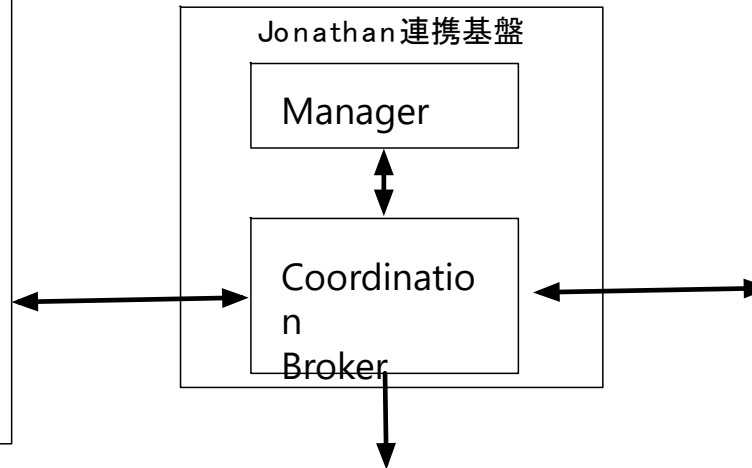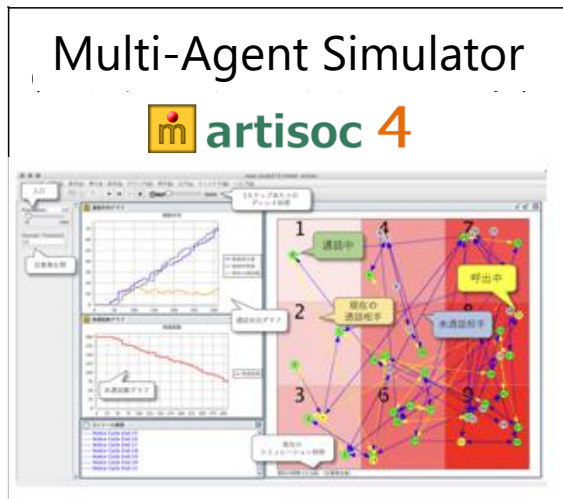
Management of **5000 virtual servers** cluster

Management of **100 physical servers** cluster

High-availability capability for Neutron network controller

Virtualized networking with VXLAN

In Progress: Integrating ICT Emulator and Simulator

Multi-Agent Simulator
artisoc 4

Jonathan連携基盤
Manager
Coordination Broker

The Emulator
StarBED

可視化基盤
（Unityで実装）
unity

- Simulate start/holding time of communication by users
- Link these events to the StarBED emulator

- Emulator on StarBED
- Real traffic generated from the simulator's trigger
- Feedback to the future simulator events

Visualization for overall state