NICT's R&D and Promotion activities on the terrestrial radio system/network designs toward the future

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The sole national research institute in the field of ICT in Japan

- Cooperating with and supporting industry and academia
- Three roles: Research institute, Research funding agency, Public service agency

Public Services:
- Japan Standard Time
- Space Weather Forecast
- Wireless Equipment Testing & Calibration
- Cybersecurity Training

Personnel: ~ 1100
- Researchers: ~ 530
- PhDs: ~ 460

- Creating new value through ICT
- Building a new ICT society

R&D carried out by NICT’s researchers
Support for R&D in industry and academia
Promotion of ICT industry

Growth of Japanese economy
Safety and security for a more convenient life
Contribution to solve major problems of the global community

NICT HQ @Koganei, Tokyo
National ICT Policy

Collaboration with Industry - Academia – Government
Challenge to provide future radio communication systems

- The effective radio resource utility to satisfy the complicated and diversified demands on 5G and B5G has the highest priority in the NICT’s R&D activities on the terrestrial radio communication technologies

  - R&D to provide required Availability and Connectivity for the 5G/B5G network and services:
    - 5G/B5G-Availability by introducing the private microcell structure
    - 5G/B5G-Connectivity by the low-latency and massive-connection access
  - Are potentially supported by auxiliary technologies for further enhancements

R&D on 5G/B5G to satisfy Complicated & Diversified demands by:

- Availability:
  - Private microcell

- Connectivity:
  - Low-latency & massive connection

Supporting Technologies:

- Wireless grid
- Flexible factory
- Enhanced reliability

Ref.: ITU-R M.2083: IMT Vision - "Framework and overall objectives of the future development of IMT for 2020 and beyond"
NICT has employed the private area that is realized by microcell structure to support 5G applications.
NICT has studied on the suitable information exchange interface among the microcell operators and cellular operators.

Necessary interface to provide operational information (location, frequency, etc.) for microcells deployed in the private area.

- Core network (Cellular Operator A)
- Core network (Cellular Operator B)
- Public Area (Areas for conventional cellular)
- Private Area (Areas for the deployed microcells)
- Offices, train stations, factories, shopping malls, universities, homes, etc.
Proof tests confirm that the **smart office environments** are effectively realized by introducing 5G/B5G system capabilities.

**Smart chair**
Embed sensors for posture detection with high spec solar panel for battery less operation

※ Bluetooth Low Energy (BLE) is used for smart chair instead of standardized 5G system

**Smart table**
Allows devices just on the table to communicate
Hence, enables wireless communications without interference from other tables

* 5G systems for eMBB and URLLC are emulated with currently standardized specifications adapted for frequency bands assumed for 5G
Availability (4): ITS Proof Tests

- Proposed microcell structure is evaluated in ITS proof tests that employ the developed **traffic e-mirror**
  - Secure safety in **non-line-of-sight spots**
  - Road sensors recognize traffic environment in real-time
  - Flexible deployment using wireless systems
NICT has proposed the new access control scheme **STABLE (Simultaneous Transmission Access Boosting ultra-Low-latEncy)** that enables massive connection and low-latency.

**Massive connection**
- **Non-Orthogonal Multiple Access (NOMA)**

**Low Latency**
- **Grant Free (GF)**

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Conventional technique:
- Step 1: Random Access Preamble
- Step 2: Random Access Response
- Step 3: Scheduled Transmission
- Step 4: Contention Resolution

GF:
- UEs can transmit signals without grant.

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**Diagram:**
- **Base Station (BS)**
- **User equipment (UE)**
- **Frequency**
- **Time**
- **Conventional technique**
- **NOMA**
- **Resources can be shared by multiple UEs.**
Connectivity (2): Proof tests of “STABLE”

- Massive-connection and low-latency capability of “STABLE” is confirmed in the proof tests in YRP area

Massive connection: 4.5 UEs can be decoded on average
Low Latency: 3.9 milliseconds

These plots were printed on the picture of the Geospatial Information Authority of Japan
Supporting technologies (1): Wireless grid technology

- NICT has studied on the **wireless-grid** that consists of radio device grid topology and becomes one of the promising technologies for **IoT applications** in the future.

- Conventional smart meter system (SUN) is effectively exploited.

Proof tests in the laboratory and in the real rice field

Environmental sensing experiments using sensor devices

This work was supported by Cabinet Office, Government of Japan, Cross-ministerial Strategic Innovation Promotion Program (SIP), "Technologies for creating next-generation agriculture, forestry and fisheries" (funding agency: Bio-oriented Technology Research Advancement Institution, NARO).
Supporting technologies (2): Flexible Factory Project

- **Efforts to solve real problems in the manufacturing sites**
  - Revealing crucial requirements for wireless communications
  - Conducting wireless environment evaluation and wireless packet transmission tests at factories in operation
- **Collaborating work since 2015**
  - NICT and 14 companies doing field experiments at 8-factories in operation
Supporting technologies (3): R&D on Enhanced Reliability

- Technologies to establish radio communication links under **severe** conditions of infrastructure and propagation, thereby **enlarging** radio applicable fields

**Regularity**

Tele-control of drones or robots

**Availability**

- Disaster-tolerant networks

**Connectivity**

- Multi-hop communications with deterministic latency

- Restricted wireless communications

- Under-seawater communications

  Joint research with JAMSTEC
The effective radio resource utilization to satisfy the complicated and diversified demands on 5G/B5G has the highest priority in the NICT’s R&D

- R&D to provide Availability and Connectivity for the 5G/B5G network and services:
- Are potentially supported by auxiliary technologies for further enhancements

Cope with Vertical sectors via Physical Cyber Systems

R&D on 5G/B5G to satisfy Complicated & Diversified demands by:

- Availability: Private microcell
- Connectivity: Low-latency & massive connection

Wireless grid Flexible factory Enhanced reliability

Digital Transformation Foundation
Enhanced Access
Integrated Mobility
Area Expansion
Next Gen. IoT

Supporting Technologies:

We are now in the standardization and promotion phases based on the preliminary system designs and proof tests.

FY2018: Spec. finalization, Tests, Collaboration
FY2019: Standardization, Promotion
FY2020: Reflected in the social system and the regulation
FY2021+: R&D on the radio utilization in CPS era