Wireless Connection Now and in the Future

National Institute of Information and Communications Technology

Wireless Networks Research Center

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Connecting the Unconnectable toward the Next Generation and the Future Ahead

The National Institute of Information and Communications Technology (NICT) has a long history of studying wireless communication systems. It began with the study of radio telegraphy in 1896 at the Radio Telegraph Division of Electrotechnical Laboratory of the then Ministry of Communications. This was the starting point of the study on wireless communications in Japan.

Since then and up until today, wireless communication technologies have remarkably evolved from radios and televisions to cell phones and satellite communications, enabling us to communicate with each other and transfer data from various places and environments. When the eagerly awaited 5th-generation mobile communication system (generally called “5G”) finally becomes available, the Internet of Things (IoT) where everything will be tied to the Internet, and the artificial intelligence (AI) will be commonly used. This is expected to revolutionize our society.

Meanwhile, various issues may arise; the depletion of frequency resources caused by an explosive growth of traffic in the field of wireless communications, ensuring communication during a major disaster on land or from the sea, and the digital divide between cities and rural areas.

The Wireless Networks Research Center of the NICT is engaged in research and development of wireless networks that can connect the “unconnectables” in any circumstance and environment on land, in the sea and up in the air, disseminating wireless technologies and systems that enable us to realize a rich and environmentally sound communication system looking ahead into the generation that follows and thereafter, in a sustainable manner, with a view to realizing an ultra-smart society called “Society 5.0,” a concept of a future society that Japan should aspire to.
Create value and unprecedented security within an ultra-smart society by promoting need-based research and development.
Creating Information Distribution Infrastructure for an Ultra-Smart Society by Connecting Every Person and Thing

The Wireless Systems Laboratory is mainly engaged in research and development of fundamental technologies and system configurations that are required for the future terrestrial wireless networks, which include the radio communication technologies to provide 5G and beyond-5G mobile communication systems and to promote IoT systems. The aim of those research and development activities is to realize the effective utilization of frequency resources and safe and secure wireless communications.
Wireless Systems Laboratory

A | Wireless Network Management Technology

This technology provides infrastructure enhancement that includes ultra-high-speed transmission using millimeter and terahertz wave, thereby realizes effective frequency utilization required for 5G and beyond-5G mobile communication systems.

B | Wireless Network Customization Technology

This technology enables a terminal to properly alter the level of functions depending on situations to ensure collection of data which is essential for building a big data source for use and routine application of IoT and AI.

C | Wireless Network Reinforcement Technology

This technology enables radio applicable area expansions by providing the radio links with low-latency and high-availability, which include radio connection establishment under severe radio propagation conditions thereby enable time sensitive radio communication network among robots/drones, robust undersea radio sensing/communication, and human body area network employing implantable radio devices.

Information distribution base to support IoT (IoE*)

*IoE: Internet of Everything
5G smart office and 5G disaster-resistant warehouse

Focusing on the massive Machine Type Communications (mMTC) which is one of the features of 5G, NICT has proposed the use and the application of 5G in offices and warehouses in the 5G Comprehensive Demonstration Test* led by the Ministry of Internal Affairs and Communications, and played a leading role in relevant development projects.

Wireless technology for ultimate environments (underwater/medical implant communication)

Research and development of this technology includes underwater wireless technologies enabling wireless communication with an underwater research robot for marine resource exploration, and low-power wireless technologies to establish a position estimation system for a swallowed device in the human body.

* 5G Comprehensive Demonstration Test:
The project was launched in FY 2017, and stakeholders in various utilization fields have participated in this test in an attempt to create a new market with the realization of 5G.
Flexible Factory Project
This is the world’s first joint project involving all related industries to achieve collaborative control of various wireless systems and stable communication in a wireless environment at a factory in operation with a future objective of introducing IoT to factories.

Next-generation smart electronic traffic mirror
A technology to prevent accidents and road congestion by showing the roads behind buildings or beyond the seeable range to pedestrians and vehicles through electronic traffic mirrors equipped with built-in cameras and sensors. Unprecedented mobility services can be expected by linking this technology to big data and AI.

STABLE: Wireless access technology to fulfill the technical requirement on massive connection and low latency for 5G
A technology that improves the frequency usage efficiency 2.5 times the present efficiency by applying massive Machine Type Communication (mMTC) to the real-time control of machine tools and robots, and at the same time, realizing an Ultra-Reliable and Low Latency Communication (URLLC).

Device-to-Device (D2D) wireless network technology
This is a wireless network technology, allowing various devices/terminals to autonomously establish a network with other devices/terminals within an area for communication at a 920 MHz band. Because it is independent of the existing infrastructure, this technology reduces operation costs and is useful for various applications including evacuation guidance in the event of a disaster.

Flexible Factory Project

Wireless technology for safe operation of drones beyond line-of-sight
Demonstration experiments have been conducted jointly by related institutions for wireless technologies developed at this laboratory, such as “Command Hopper,” a technology, which realizes remote control and monitoring of robots and drones out of sight such as in a mountain area where numerous obstacles could interrupt radio wave transmissions, and then comes the “Drone Mapper” technology, which is a positional information sharing system, capable of avoiding collision of drones and manned helicopters in the air and controlling their operation.
Satellite Communications of a New Age with Global Networks Integrating Space and Ground

When 5G is put into practical use, areas and environments where ground communication is difficult at present will be connected, and it is expected that IoT will be connecting people and every sort of things via wireless communication, and more advanced IoE are expected to be widely disseminated. However, 5G services still remain unavailable in the sea for absence of base stations, and in remote areas, such as in the mountains where radio waves cannot reach, or when base stations are damaged due to an emergency or disaster.

To solve this problem of connectivity, the laboratory has been carrying out research and development aiming at constructing space-ground integrated networks with a view to use big space data in space by combining optical satellite communication and Ka-band satellite communication systems to support 5G communications.
The technology under development is intended to be used in the development of a high throughput satellite (HTS) using multibeam systems based on Ka-band broadband satellite communication technologies to provide 100-Mbps class satellite communication links for ships at sea including marine resource research vessels, for in-flight communications of aircraft and in the event of disaster.

In response to increasing communication demands for larger capacity satellite communications and in preparation for the shortage of frequency resources, the technology is intended for use in the research and development for the onboard 10 Gbps class laser communication terminal and improvement of the quality of communications. The international collaboration of site diversity technology will be demonstrated through the global collaboration with international space agencies and institutions as the world-leading demonstrations.
A

Space/ocean Broadband Satellite Communications Network Technology

Ocean and space broadband satellite communication system
Under development is a technology to provide broadband circuits, required for operating Engineering Test Satellite IX (ETS-IX)*1 at sea and in air routes in a flexible manner using radio waves. In addition, smaller and lighter components that go along with this technology are also being developed.

Next-generation marine resource investigation technologies
Participating in the “Next-generation Marine Resource Survey Technology (Zipangu in the Ocean Program)” which is part of the “Cross-ministerial Strategic Innovation Promotion Program (SIP)” promoted by the Council for Science, Technology and Innovation (CSTI) of the Cabinet Office, the laboratory has developed technologies for networking research vessels, transponders on the ocean and onshore base stations via high-speed satellite communications.

B

Global Optical Satellite Communications Network Technology

Small transponder (SOTA) project
Small Optical TrAnsponder (SOTA) and Very Small Optical TrAnsmitter (VSOTA) that can be mounted on a 50-kg-class micro-satellite were developed to be used for optical communication experiments between the satellites and the ground station.
Technology for electronically-scanned array antennas that can be installed aboard small commercial aircraft

The R&D of a technology for the efficient frequency use to achieve faster communications without altering the antenna size is in progress to meet the needs of Internet service providers for offering stress-free viewing and listening to the large-volume data contents such as videos even inside small or medium-sized aircraft.

Super high speed Internet satellite “KIZUNA” (WINDS) project

NICT has conducted research and development of Ka-band*2 satellite communication technologies using communication satellite “KIZUNA” (WINDS)*3 and has made various achievements such as 3.2 Gbps transmission rate as the world’s highest speed and the real-time 4K movie transmission of the total solar eclipse from Iwo island in 2009. These technologies have been actually used in providing disaster response by using satellite communication links, for example, in the Great East Japan Earthquake and the Kumamoto Earthquake.

* 1 Engineering Test Satellite IX (ETS-IX):
It is an engineering technology satellite scheduled to be launched in FY 2021 for developing an internationally competitive satellite system that can achieve a broadband environment mainly aiming at aircraft and ocean vessel services at low costs.

* 2 Ka-band:
One of the microwave bands in SHF-EHF band (27 to 40 GHz), 30 GHz and 20 GHz are used respectively for uplink and downlink connections in satellite communications.

* 3 Wideband InterNetworking engineering test and Demonstration Satellite “KIZUNA” (WINDS)
A communication satellite co-developed by NICT and JAXA (Japan Aerospace Exploration Agency) has been used in various demonstrations for almost 11 years since its launch on February 23, 2009. The operation was terminated on February 27, 2019.

Core technologies for global optical interorbit communication network

An ultrahigh capacity satellite communication is required for upgrading remote sensing and extensive use of aeronautical and satellite communication. To meet this need, a High speed Communication with Advanced Laser Instrument (HiCALI) is being developed to be embarked on Engineering Test Satellite IX (ETS-IX) scheduled to be launched in FY 2021.
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