Integrated ICT
Wireless Networks Research Center

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The use of wireless communications in information and communication networks has grown dramatically in recent years, becoming an indispensable part of daily life. This trend has generated a need for R&D toward technologies that can further enrich life through the use of radio waves as part of a wide-ranging network environment that includes ground, marine, and space communications. The goal here is to create new value such as the next-generation mobile communications system (5G), large-capacity satellite communications, and the Internet of Things (IoT) and to achieve systems and applications that can provide users with unprecedented reliability and peace of mind.

The Wireless Networks Research Center conducts comprehensive research and development centered about two research laboratories distinguished by their research themes with the aim of expanding the field of wireless communications. The following research on wireless network platform technologies and satellite communications technologies is being performed in conformance with the Fourth Medium- to Long-Term Plan of NICT.

Wireless network management technology

We built prototypes of privately operated microcell radio equipment for the millimeter-wave band (28 GHz) and constructed a simulation environment including management equipment and base stations. We used this environment to demonstrate the feasibility of a proposed system that could be used by multiple operators in Intelligent Transport Systems (ITS) and other real-world systems (Fig.1 (a)). Additionally, using a system for reporting the operating information (position, frequency, etc.) of microcell base stations from multiple cellular operators based on control-plane/user-plane separation, we demonstrated the possibility of integrating such "private microcells" with 5G mobile communications and proposed the necessary architecture to the 3rd Generation Partnership Project (3GPP), where it was subsequently adopted.

Next, envisioning application in environments such as emergency-supply warehouses and smart offices, we successfully conducted an indoor experiment on massive connectivity assuming 20,000 5G radio terminals. In this way, we demonstrated the feasibility of using this technology in 5G systems under massive connections on the order of 1,000,000 devices/km^2 (Fig.1 (b)).

Furthermore, as a technology contributing to efficient frequency utilization, we conducted a basic experiment on massive connectivity under the conditions of five simultaneously connected terminals and a latency time of 5 milliseconds (ms) or less. We submitted a portion of these experimental results to 3GPP RAN 1 as a draft contribution. We also proposed a control system to enable high-density rollout of microcells and submitted a partial system as a draft contribution toward the next-generation wireless LAN standard (IEEE802.11ax). This contribution was accepted and is now under discussion. In addition, we proposed an extended Multipath TCP (MPTCP) system to the Internet Engineering Task Force (IETF). The purpose of this system is to individual applications to operate at desired transmission speed and latency in combination with deep packet inspection technology while simultaneously connecting multiple cellular operators and enabling the sharing of resources on the transport layer.

Wireless network customization technology

Among network structures consisting of multiple units of radio equipment (wireless grid), the high-reliability mesh network is laying the foundation for new application fields. For this type of network, we studied the modeling of various wireless adaptation formats for in-factory use and successfully obtained data in a real-world environment in conformance with wireless applications (some 130 types) that we analyzed and categorized last fiscal year. We are working to deploy this technology in society by proposing it to a working group of the IEEE 802.1 standard committee and promoting its reflection in a white paper. Additionally, for large-capacity data collection networks consisting of a large-scale mesh of many wireless terminals, we extended the Layer 2 Routing (L2R) specification as an IEEE 802.15.10 recommended practice in fiscal year 2016 and successfully demonstrated data concatenation, virtualization, and other functional enhancements. Then, as an agricultural application of an ultra-low-energy network using battery-driven wireless terminals, we successfully demonstrated low-energy wireless operation for both data collection and control in a real agricultural field.

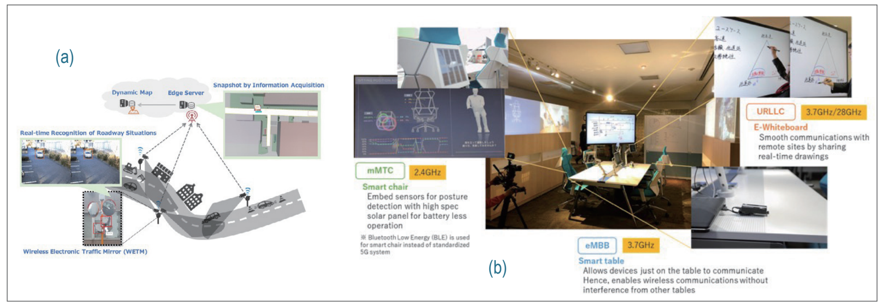

Fig.1 : Wireless network management technology: (a) demonstration of ITS using privately operated microcells, (b) demonstration of a smart office using 5G wireless terminals

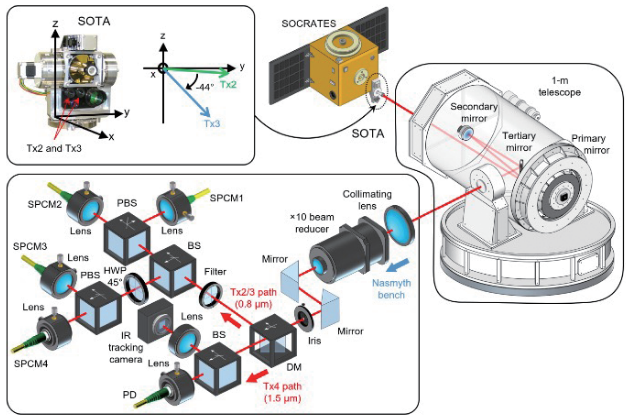

Fig.2 : World's first satellite-to-ground, quantum-cryptography basic experiment using SOTA

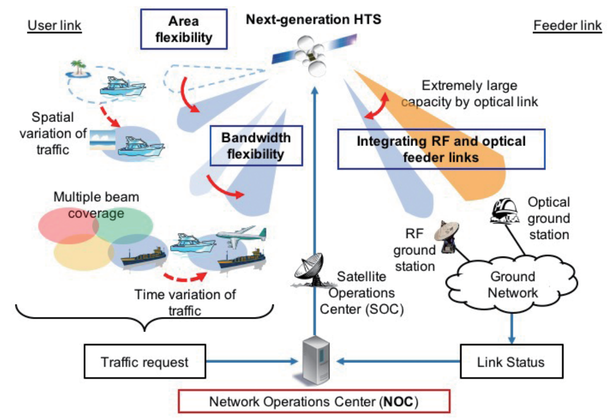

Fig.4 : Conceptual model of high-efficiency control system

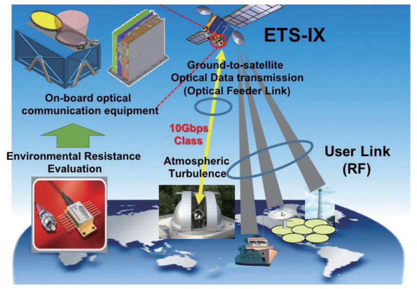

Fig.3 : Basic configuration of optical feeder link experiment using ETS-9

Wireless network reinforcement technology

We proposed a PHY/MAC system for distributed inter-terminal communications and took a leading role in formulating the IEEE 802.15.8 standard. We also developed an impulse-radio ultra-wideband (IR-UWB) positioning system and promoted system verification trials in Southeast Asia. In addition, we studied latency-guaranteed wireless network technology (maximum allowed latency: 20 ms) for transmitting on-vehicle sensor data for application to the IEEE 802.15.8 UWB system. Furthermore, in relation to latency-guaranteed, multi-hop relay control communication systems for ensuring the safe operation of non-line-of-sight robots or drones, we designed and developed a frequency-redundant-type system using a new robot band and successfully performed a verification experiment targeting the flying of drones. We also conducted joint research with a major power infrastructure operator toward practical deployment of this technology.

Global optical satellite communications network technology

We performed optical satellite communications experiments between a low-orbit satellite and a ground station using an on-board laser communication terminal called Small Optical TrAnsponder (SOTA), and successfully performed the world's first basic quantum-communications experiment for a 50-kg-class micro-satellite (Fig.2). This achievement was published in Nature Photonics and turned out to be more successful than expected.

Next, with a view to performing space communication demonstrations using Engineering Test Satellite IX (ETS-IX), we completed the preliminary design for the on-board equipment of ultra-high-speed optical communication equipment called HIgh speed Communication with Advanced Laser Instrument (HICALI) for achieving 10-Gbps-class transmission speeds between a stationary satellite and ground station as a world's first (Fig.3). Additionally, after working on the development of ultra-high-speed optical satellite communication devices for on-board use in the form of consigned research, we use the results of this work to establish a screening process for space-environment tolerance tests for commercial off-the-shelf (COTS) optical communication devices.

We also participated in standardization activities for space laser communications in the Consultative Committee for Space Data Systems (CCSDS) founded by major space agencies around the world and contributed to the first official report for space laser communications.

Space/ocean broadband satellite communications network technology

The Wireless Networks Research Center led the drafting of overall requirements for ETS-IX communication missions, promoted R&D of flexible satellite traffic control technology and on-board fixed multi-beam communication equipment as the representative research institution, and completed a preliminary design. Additionally, with regard to high-efficiency operation and control technology for a non-conventional RF/optical hybrid satellite communication system proposed by NICT for ETS-9 demonstrations, we studied a basic model in fiscal year 2016 and designed a conceptual model of a control system in which a Network Operation Center (NOC) manages frequency and beam variation and RF/optical feeder link switching (Fig.4). We also fabricated the basic components of a simulator for testing these functions. In addition to the above, we performed a series of measurements of mobile-terminal propagation characteristics in the Ka-band using the WINDS satellite.

In the area of international standardization, we participated in the standardization of an integrated Mobile Satellite Services (MSS) system within the Asia-Pacific Telecommunity (APT) as part of the APT Wireless Group (AWG) and contributed to the completion of a new report reflecting NICT proposals.