Wireless Access Technologies to Provide Various Services in Future Networks

Hiroyuki Nakamura

Abstract

NTT Access Network Service Systems Laboratories is researching and developing wireless access technologies in two of its laboratory projects. This article introduces the wireless technologies being developed that will contribute to providing advanced mobile services of the 202X generation. These include future network services in the NTT Group as well as telephone services for extremely rural areas and essential services for disaster recovery.

Keywords: unlicensed band radio access, fifth-generation system, radio systems for telecommunications operators

1. Introduction

A wide variety of communication services can be enjoyed in a mobile environment. Furthermore, in the 2020s, it is expected that the existence of high-speed mobile communications will make it possible to offer numerous ICT (information and communication technology) services and that new value-added services will be achieved thanks to the Internet of Things (IoT). To make this a reality, there will be a need not only for higher speeds in the wireless system but also for optimal end-to-end quality and flexibility to achieve diversity. At the same time, providing telephone services in extremely rural areas and a means of communication to preserve essential services for disaster recovery is becoming increasingly important.

2. Wireless access technologies for 5G*/5G+ era

Mobile communications data traffic is increasing annually by approximately 1.4 times [1]. However, as content becomes further enriched and the use of the communications infrastructure becomes increasingly diversified, we can expect the total data traffic in wireless access to increase all the more in the 2020s. In wireless access at present, communication via mobile networks provided by carriers and communication via wireless local area network (LAN) are roughly equal in terms of traffic volume. In this regard, unlicensed radio bands such as wireless LAN have so far been individually controlled and utilized by users. However, the era is fast approaching in which wireless systems using unlicensed radio bands will take on a larger role in handling this ongoing increase in traffic (**Fig. 1**). In this era, technologies for overlapping and seamlessly controlling mobile networks and unlicensed radio bands and for enabling the expansion of base stations and access points (APs) in massive quantities will be important for achieving an environment in which users can enjoy high-quality services. In particular, we believe that some means of controlling unlicensed radio bands and APs used and installed by users themselves is key to achieving such an environment, and we are therefore developing the specific technologies described below.

* 5G: fifth generation

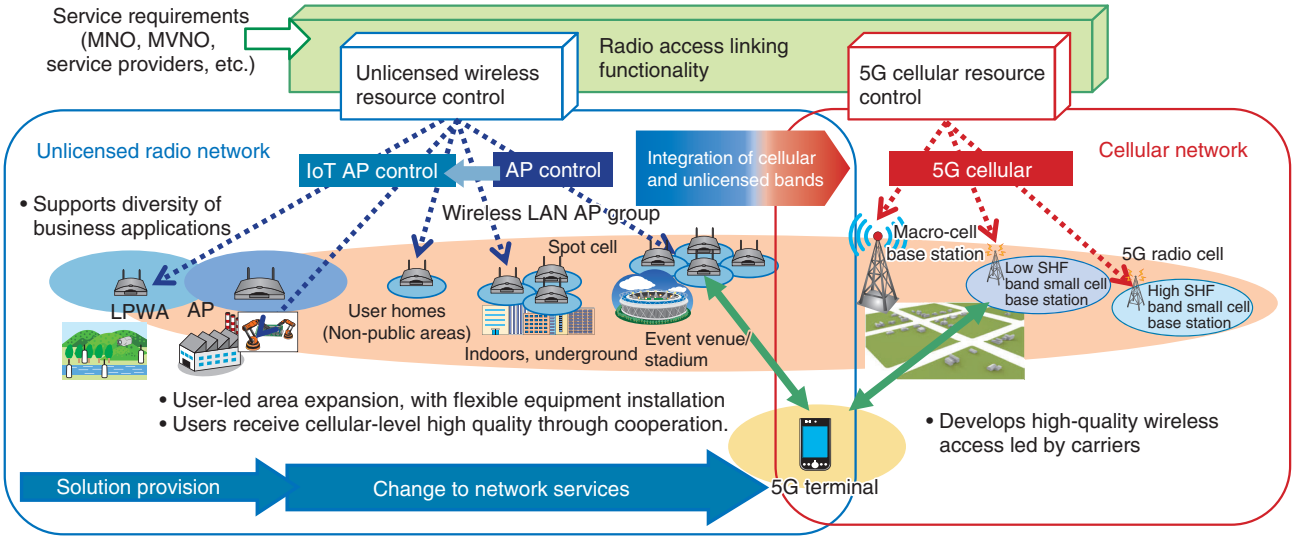

Fig. 1. Integration of cellular/unlicensed bands.

2.1 Technologies for linking unlicensed radio band systems

Various wireless standards for radio access in unlicensed radio bands have been developed for different uses, so it is envisioned that users will install APs as they see fit according to their target applications. To manage these APs across the network in an optimal manner, our aim is to achieve radio resource management through an unlicensed-band platform and software-based white-box radio base stations. Additionally, as part of the 5G comprehensive demonstration test launched in 2017 by the Ministry of Internal Affairs and Communications of Japan, some of these technologies will be used in the deployment of high-density wireless LAN and in control tests of wireless LAN linked to 5G cellular [2].

2.2 High-capacity wireless relay technology

We aim to promote the deployment of small-cell base stations and APs in massive quantities and are therefore studying high-capacity wireless relay technology in order to replace some relay lines with wireless networks in locations where the laying of optical fiber is difficult (**Fig. 2**). For this technology, we are assessing the use of high-frequency bands such as the millimeter-wave band capable of comparatively high-capacity transmission, but there is also a need for technology that can simplify installation requirements and achieve high efficiency. To solve these issues, the NTT laboratories are developing spatial multiplexing technology in the millimeter-wave band capable of high-capacity communications, antenna high-gain technology based on large-scale arrays to compensate for propagation loss, and point-to-multipoint technology for simultaneously accommodating multiple stations.

2.3 Next-generation advanced wireless LAN technology

We are developing next-generation wireless LAN technology to provide unlicensed-band radio with sophisticated functions. Up to now, wireless LAN standards have been progressing as part of efforts to increase throughput in one-to-one communication and improve the area coverage rate. Recently, however, throughput degradation in dense environments, for example, congested train stations, has brought to light the problem of how to improve communication quality in such environments. To solve this problem, the NTT laboratories have developed distributed smart antenna technology that performs high-speed switching among multiple antennas in units of packets at a wireless LAN AP and an algorithm for performing optimal control of the radio resources (frequency channel, transmission output, etc.) (**Fig. 3**). We tested this technology in an actual stadium and

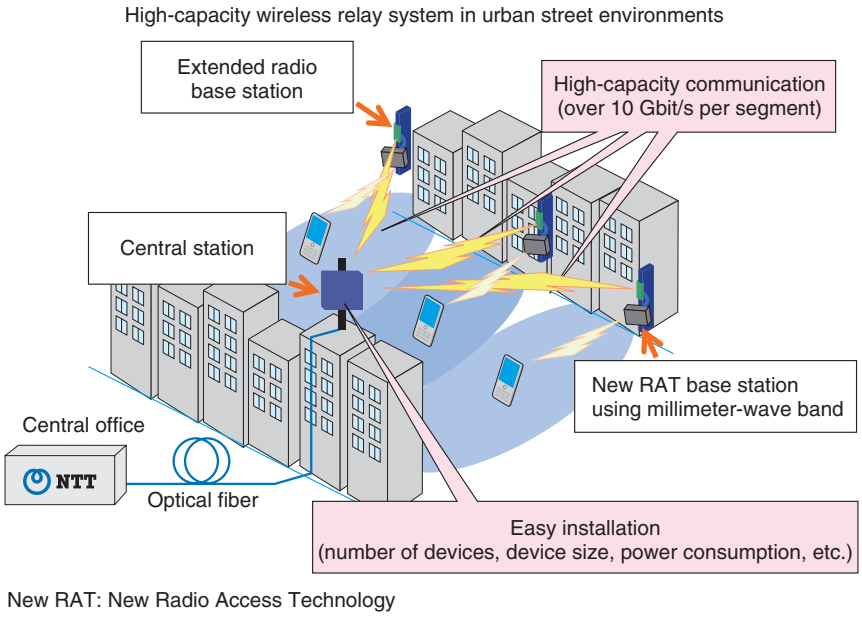

Fig. 2. High-capacity wireless relay technology.

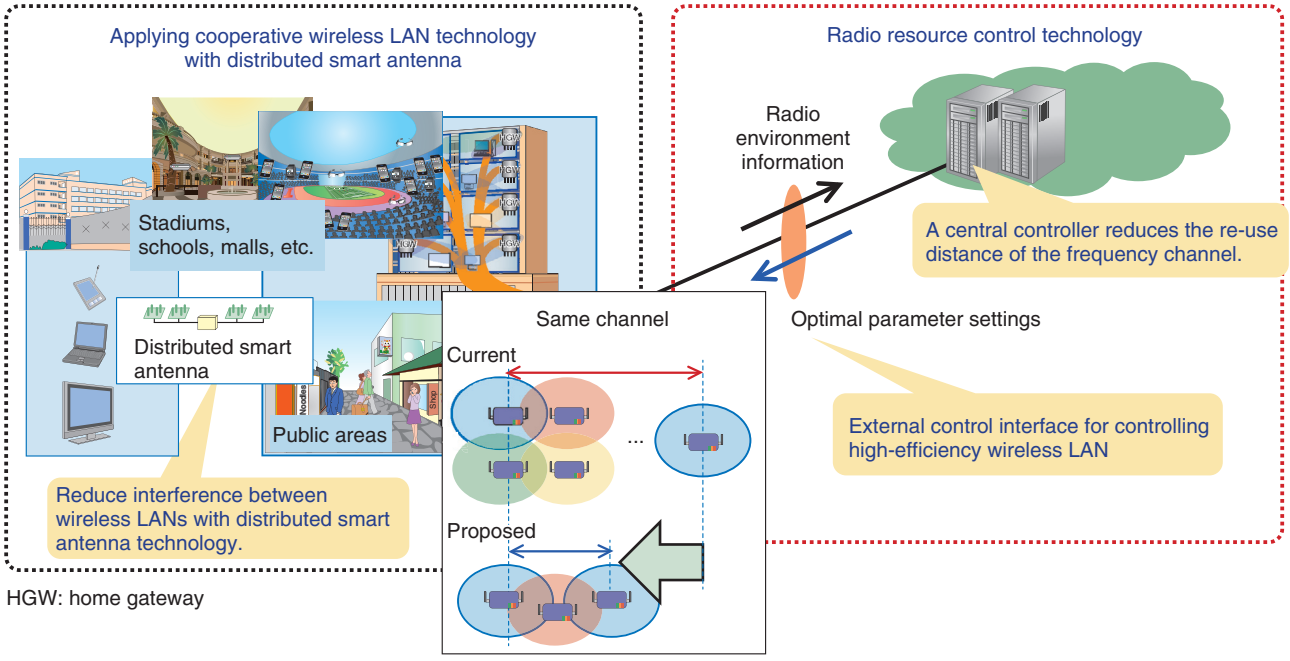

Fig. 3. Cooperative wireless LAN technology with distributed smart antenna system.

found it to be effective in reducing signal interference between APs and in improving transmission speeds even for densely installed APs [3].

At the same time, we have been promoting the drafting of related standards and have participated in formulating the IEEE (Institute of Electrical and Electronics Engineers) 802.11ax standard for achieving high transmission efficiency in dense environments

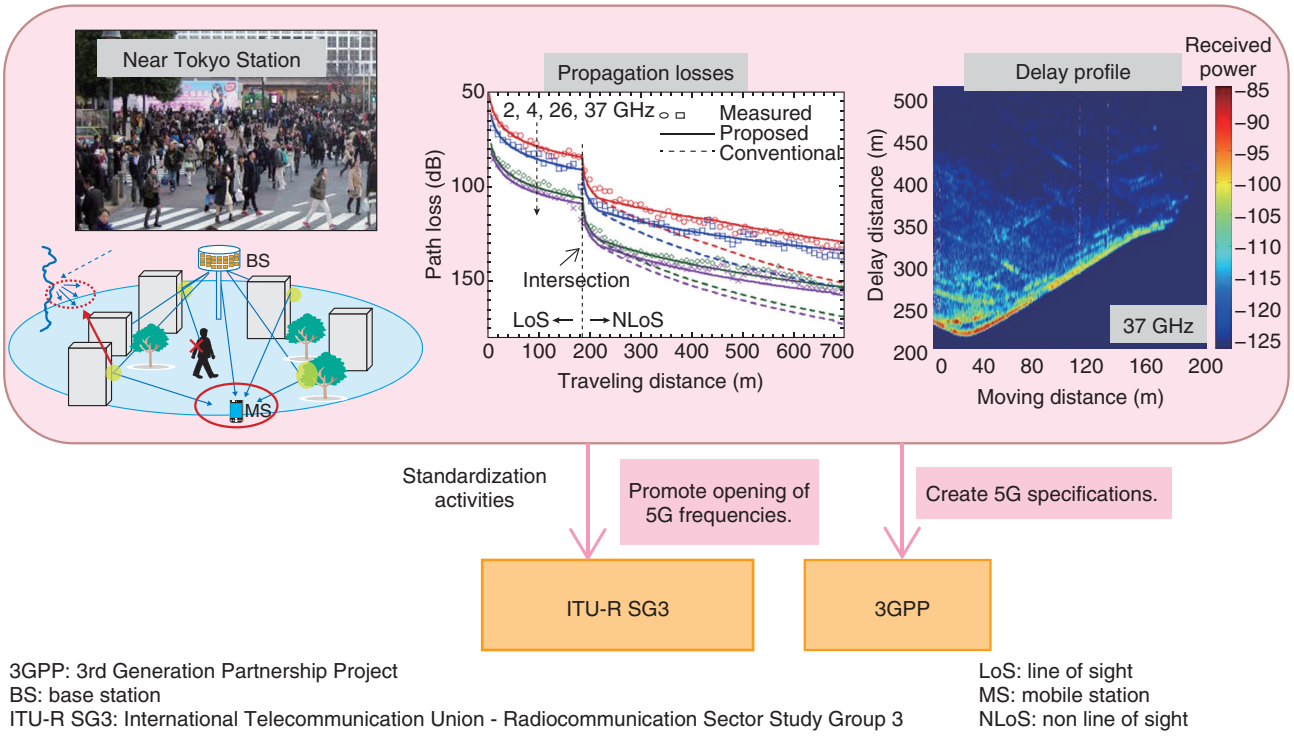

Fig. 4. Investigation of radio propagation models for 5G+.

since the task group was established for this purpose in May 2014 [4].

2.4 Multi-frequency signal propagation modeling technology

Technology for modeling the characteristics of wireless signal propagation is essential to all wireless communication systems, including 5G/5G+. The NTT laboratories have established a new method of frequency allocation through a study on ongoing coexistence with current wireless systems plus a new system design and communication method through an evaluation of propagation characteristics. We have been reflecting these new methods in cell design and area design according to the propagation conditions of individual locations.

More recently, we have been conducting propagation measurements and modeling using multiple frequency bands in the 800 MHz–66 GHz range in diverse environments, including urban and congested environments that are expected to become key targets of 5G/5G+ (**Fig. 4**). We are working to standardize these results as part of standardization efforts at ITU-R (International Telecommunication Union - Radiocommunication Sector) and 3GPP (3rd Generation Partnership Project) with the aim of promulgating new methods and specifications for frequency allocation.

3. Use of wireless systems to provide essential services, and related activities

The NTT laboratories are researching and developing wireless systems for telecommunications operators. These mainly consist of wireless systems to provide communication services to extremely rural areas not conducive to the laying of optical cable, for example, mountainous areas and isolated islands, and wireless systems to provide customers with a means of communication at the time of a disaster. Each of these types of systems, in turn, features terrestrial wireless systems and satellite communications systems. These wireless systems for telecommunications operators are expected to play an important role in securing a safe and secure communications infrastructure in the future. For this reason, the cost of these systems must be further reduced, and in addition, their maintainability and operability must be improved taking into consideration the ongoing decrease in the number of radio engineers and

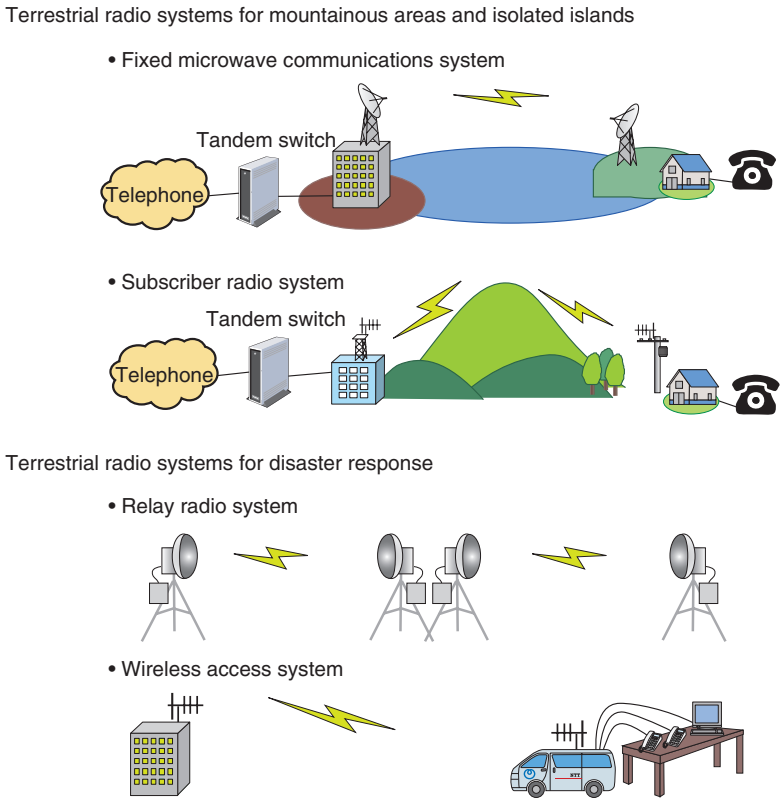

Fig. 5. Terrestrial radio systems.

technicians with advanced skills. The NTT laboratories are working to improve maintainability and operability and to reduce equipment costs using NTT technologies. The following describes current activities surrounding these systems.

3.1 Terrestrial wireless systems for mountainous areas and isolated islands

The terrestrial wireless systems for mountainous areas and isolated islands consist of a fixed microwave communications system and a subscriber radio system (**Fig. 5**). The fixed microwave communications system [5] is a wireless system that provides transmission links to areas where optical transmission paths are difficult to construct for topographical and/or economic reasons. The subscriber radio system, meanwhile, is a wireless system that provides telephone lines, for example, to extremely rural areas, mountain huts, or other remote facilities where the laying of metal or optical cables is difficult.

The NTT laboratories are expanding the applicable areas for such wireless systems through technology that achieves long-distance and high-quality transmission while increasing transmission capacity. The goal here is to bring uniformity and standardization to multiple terrestrial wireless systems and to reduce equipment costs.

3.2 Terrestrial wireless systems for disaster recovery

There are four NTT laboratories products that make up these terrestrial wireless systems for disaster recovery: a business radio system, a relay radio system, a wireless access system, and a cell and radio frequency planning tool. The business radio system [6] is a wireless system for establishing communications within a company to disseminate current disaster conditions, instructions on recovery tasks, or other necessary information to personnel in the field. The relay radio system [7] is a portable wireless system capable of high-capacity wireless communications for quickly restoring services when relay transmission paths are disrupted during a disaster. The wireless access system [8] provides special public telephone and Internet services to customers at evacuation centers and other locations at the time of a

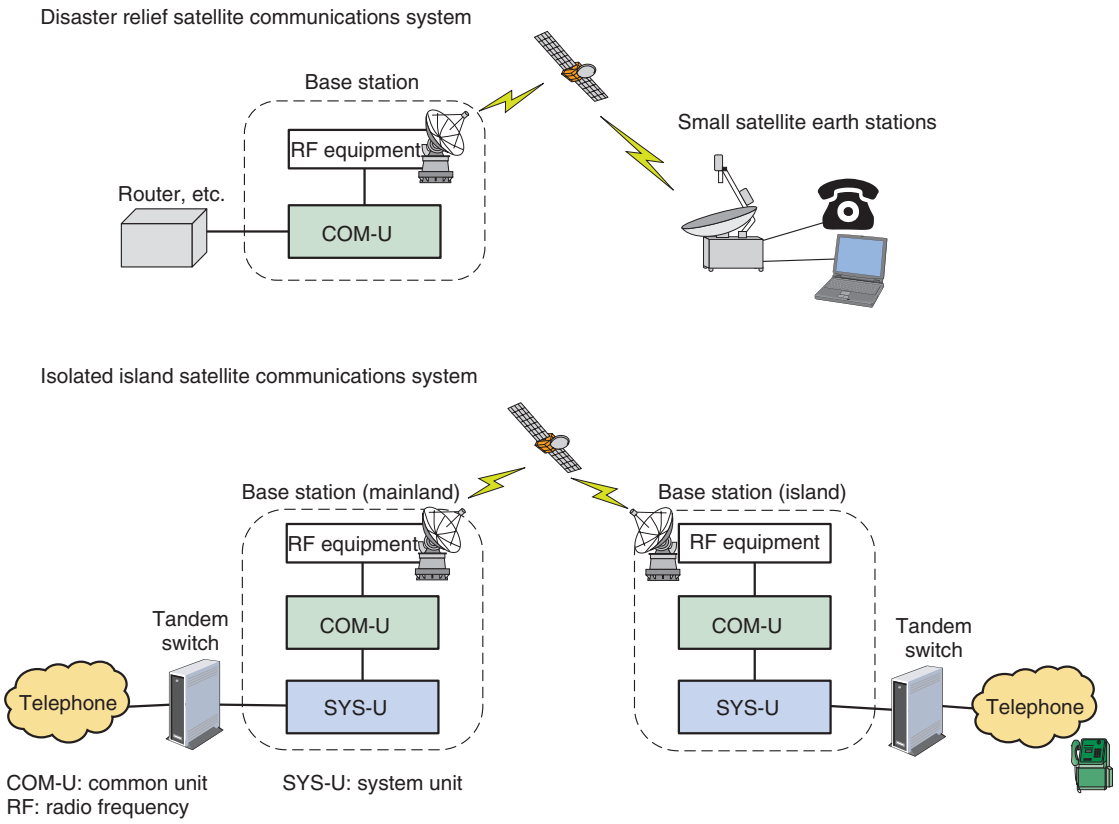

Fig. 6. Satellite communications systems.

disaster. Finally, the cell and radio frequency planning tool [9] is used to select optimal buildings for installing base stations in terrestrial wireless systems for disaster recovery.

These four products have smaller and lighter configurations and more advanced functions than past systems. The objective is to downsize the antennas in the business radio system and wireless access system to contribute to even greater portability.

3.3 Satellite communications systems

The satellite communications systems being researched and developed at the NTT laboratories mainly consist of a satellite communications system for disaster recovery and a satellite communications system for isolated islands (**Fig. 6**). The system for disaster recovery provides special public telephone and Internet services to customers at evacuation centers in the event of a disaster. The system for isolated islands provides a communications infrastructure for areas where it is difficult to lay submarine optical cable.

We have developed a satellite communications modem unit, or common unit (COM-U) [10] that can be applied to base stations in both types of satellite communications systems. COM-U enables frequency placement to be set as desired and therefore improves spectrum utilization efficiency compared with existing satellite communications modem units. Furthermore, although current satellite communications systems combine multiple pieces of equipment, the equipment is consolidated and mounted on a single rack, thereby eliminating the need for wiring and improving maintainability and operability.

4. Future outlook

At NTT Access Network Service Systems Laboratories, we are contributing to the rollout of diverse mobile services using wireless LAN to deal with the accelerated increase in traffic that can be expected with the coming of a full-scale 5G era.

Additionally, considering that the number of radio engineers and technicians is expected to drop in the

years to come, we are working to improve operability in radio systems used by telecommunications operators. At the same time, we are helping to further reduce the burden placed on operators caused by the migration of multiple radio systems and contributing to the development of low-cost radio equipment.

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■ **Author profile**

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He received a B.E. and M.E. in mechanical engineering from Keio University, Kanagawa, in 1991 and 1993. Since joining NTT in 1993, he has mainly been researching and developing wireless access systems. He has been with NTT Access Network Service Systems Laboratories since 2008. He is currently head of the Wireless Entrance Systems Project. He is a member of the Institute of Electronics, Information and Communication Engineers (IEICE).