

# Improved Dependability of Next Generation Mobile Communications Technology

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## Abstract

The spread of the mobile phone and wireless LAN has made it a matter of necessity to improve their dependability as life-support lines. This paper introduces dependability improvements for the next-generation mobile phone systems that are currently being standardized as well as outlining the efforts being made for improving the dependability of wireless LAN/WiMAX, which is designed to provide open, low-priced wireless communications.

## Keywords

next-generation mobile phone systems, dependability improvement, wireless LAN, WiMAX

## 1. Introduction

Currently deployed to about 90 million units in the Japanese market, mobile phones are now considered to be indispensable for daily communications. Mobile phone technology has been developed aiming at establishing the mobile phone as a life-support line that enables communications anytime, anywhere and for anyone. However, in the future, the development of the mobile phone will be influenced by requirements for further improvements in its robustness and for providing the end users with services that are not in any way inferior to the cable communications systems.

On the other hand, wireless LANs have been developed to provide wireless data communications for homes and hot spots, and these are also subject to the requirements of improved robustness as a means of a wireless access to enable the integration of cable and wireless services.

This paper introduces technologies for improving the safety and convenience of the next-generation mobile communications, particularly focusing on the mobile phone, wireless LAN and WiMAX systems.

## 2. Stability Improvement Technologies for Next-Generation Mobile Phone Systems

The next-generation mobile phone service is scheduled to be introduced around 2010 and to be standardized at 3GPP, aiming thus at achieving a maximum communication rate of 100Mbps (downlinking from the network to terminals), reduc-

ing the connection time, improving the affinity with IP networks and accommodating multiple wireless access systems.

Below, we first introduce network architectures for the next-generation mobile phone system and then discuss element technologies, such as network-based localized mobility management and wireless space utilization technology.

### (1) Wireless Network Architectures

In order to improve the stability of communications, the mobile phone system is required to execute a more complicated control function than cable communication systems in managing the locations of terminals, the mobility management of communicating terminals and of wireless resources. In the case of the traditional mobile phone systems, the execution and management of these functions have been centralized at network nodes called the wireless base station controllers. However, as the area covered by each base station controller is so wide, a fault in the controller makes it impossible to provide a service for the whole of the coverage area.

To deal with this problem, the next-generation mobile phone system will use a distribution architecture (**Fig. 1**) so that, even when a fault occurs with a device, the shutdown of the service is limited to within the area covered by the wireless base station and the stability of the system is thereby improved. In this system, the location, mobility and wireless resource management functions are distributed via individual wireless base station devices. However, a more fine-tuned control system than before is assumed by exchanging various information via interfaces installed in a mesh linking the wireless base stations.

In addition, the wireless and core networks are also connect-

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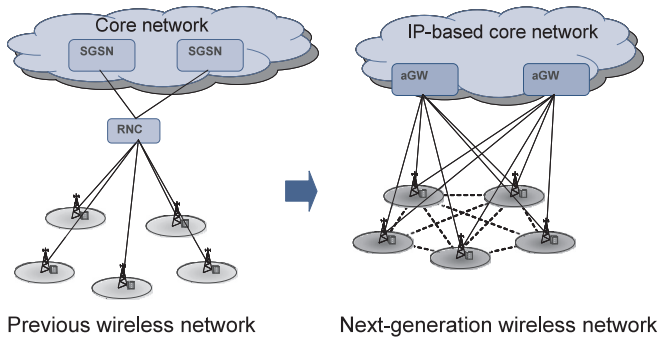


Fig. 1 Architecture of the next-generation mobile network.

ed via multiple interfaces to enhance the network robustness.

### (2) IP-based Mobility Management Technology for Core Networks

The research into the all-IP mobile network of the next-generation that involves the application of IP mobility, and of IP mobility protocol based on network leadership, which is being standardized by the NETLMM (Network-based Local Mobility Management) Working Group of IETF, is attracting attention as an optimum implementation protocol.

With the Mobile IP protocol that is currently used for the Internet, the terminals register their own positions in anchor nodes (Home Agents) using the c/o IP addresses they acquire in the positions they have moved to and the anchor nodes transfers the IP packets by encapsulating them. However, with the NETLMM protocol, the position registration procedure and encapsulated transfer are executed by the access routers at the network edges (Fig. 2).

This design provides the protocol with the following features; 1) absence of degradation in mobility performance depending on the capabilities of individual terminals makes it possible to deliver uniform, high-quality mobile services to various terminals; 2) the user packets are encapsulated only within each core network and encapsulation is not required in the wireless sections of the limited bandwidth of the wireless resources. They can thus be used effectively and high-quality services can be provided; 3) with the NETLMM protocol, the addresses of the control nodes in the networks can be hidden from the terminals so that the threat of DoS attacks can be reduced and the compatibility between effective core network use and location privacy protection, which has hitherto been a problem with the Mobile IP protocol, can be achieved.

The NETLMM protocol is applied to the local mobility management in the mobility management architecture that is di-

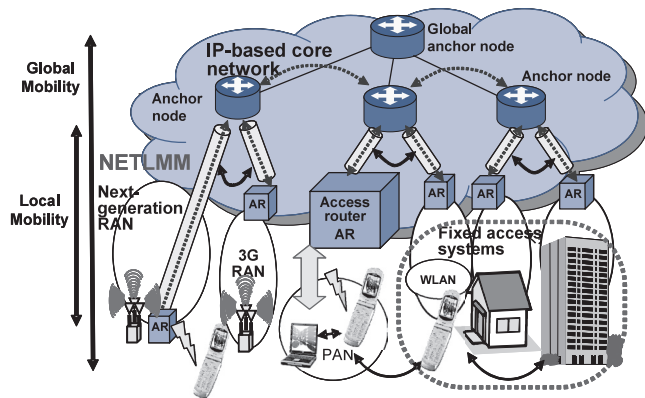


Fig. 2 Mobility management of next-generation mobile network.

vided into the global/local hierarchy. It enables fast, seamless handovers for movements within the local domain as well as linkage with the global mobility protocols (MIP v4/v6, MOBIKE, HIP, etc.) that are selected arbitrarily by the terminal users.

### (3) Effective Wireless Space Utilization Technology (MIMO)

The 3G mobile phone system uses the code division multiple access (CDMA) as its wireless access system. CDMA features a frequency usage efficiency that is higher than the frequency division access or time division access used up until the 2G system and, in the case of an overload, the system capacity degrades only gradually instead of dropping suddenly. As a result, system stability can be maintained even when users rush temporarily for an event in the uplink direction (from terminals toward the network).

In addition, CDMA can employ the same radio frequency for adjacent wireless base stations so that the allocation of radio frequencies to the stations is easily accomplished. This facility is useful for network design and modifications during regular operation as well as for early recovery after disasters and network modifications according to the recovery situations. The properties of CDMA outlined above will also be adopted for the next-generation mobile phone systems.

Currently, 3GPP is studying a variety of new technologies aiming at improving the throughput of the next-generation mobile phone systems. One of them is the MIMO (Multiple-Input, Multiple-Output) multiplexing technology (Fig. 3), which uses multiple antennas in both transmitting and receiving sides and transmits different signal trains in parallel between antennas. The system can theoretically achieve a throughput several times greater than the number of antennas using the same frequency band. It necessitates advanced re-

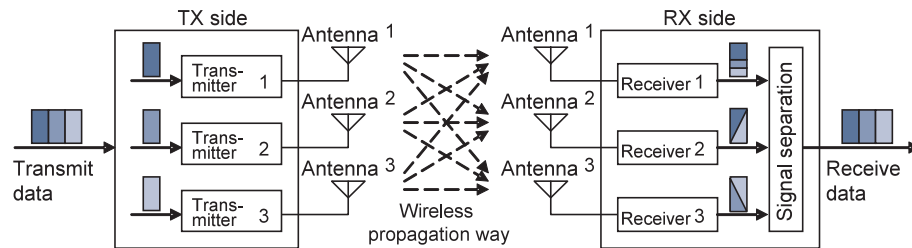


Fig. 3 MIMO multiplexing technology.

ception processing for the separation of the signals. If the MIMO multiplexing technology is used to transmit the same signal trains in parallel, it will be possible to improve the quality of communications in each service area. In addition, if signals are exchanged by forming directional beams using multiple antennas it will also be possible to improve dependability by reducing the interference of jamming waves.

### 3. Stability Improvement Technology for Open Wireless Communications

Open wireless technology such as wireless LAN and WiMAX are being deployed rapidly thanks to the capability of building networks easily at low cost. The open wireless technology has previously been accompanied by a stability problem, and improved stability is keenly required in consideration of its use as a new means of radio access in the age of FMC (Fixed-Mobile Convergence).

Below, we will introduce our efforts for improving the functions of wireless LAN as well as a network advancement technology based on the linkage of wireless LAN and WiMAX.

#### (1) Improvements in Wireless LAN Functions

Wireless LANs are being deployed rapidly as a means of simple wireless high-speed multimedia communications. Very convenient environments for their use have now been arranged, making it possible to access them from homes, offices, stations and wireless LAN hotspots as well as in airplanes. Also, dual mobile phones incorporating wireless LAN have been developed recently so that high speed communications are available when phones are located in wireless LAN areas.

Despite the convenience, the dual mobile phone has the disadvantage of large power consumption because of its incorporation in multiple wireless systems. In addition, the QoS (Quality of Service) needs to be further improved when using applications with real-time properties such as voice calls and video telephones via wireless LAN. It will be only after

the power consumption is reduced to improve the standby period and communication time characteristics and the QoS is adequately supported that the user will be able to confidently utilize dual mobile phones.

The Wi-Fi Alliance is an industry-wide association aiming at securing the interconnectivity of wireless LAN. It has started WMM (Wi-Fi Multimedia) certification for securing the contention-based interconnectivity of the QoS function, and over 200 products have already received certification.

At present, the wireless LAN is mainly used with PCs, and the range of its applications is expanding thanks to the reductions in chip sizes, reduction in power consumption and improvements in functions. In the future, its applications are expected to extend into equipment other than PCs, such as intelligent home electrical appliances and mobile phones. To meet these future needs, the Wi-Fi Alliance is studying the provision of certification according to different types of equipment in addition to its current activity of certifying interconnectivity in compliance with IEEE802.11. Various task groups are conducting studies for this purpose, including the Consumer Electronics TG dealing with intelligent home electrical appliances, the Voice TG dealing with voice calls, the Wi-Fi Mobile Convergence TG dealing with certification of mobile phone-converging terminals, the QoS TG dealing with the quality of communications and the Simple Config. TG that deals with the simplification of the network configuration of wireless LAN.

When in the future, the functions are improved and interconnectivity is secured, the wireless LAN is expected to grow further as a handy means of radio access (Fig. 4).

#### (2) Wi-Fi/WiMAX Linkage

Considering the requirement for a broadband performance that is compatible with multimedia, the next-generation network should feature high speed and a large capacity, so the use of the already widely deployed Wi-Fi (wireless LAN) technology is regarded as being an essential component. However, since the cell radius of Wi-Fi is as small as about 100 meters, it is difficult to extend the network to a broad

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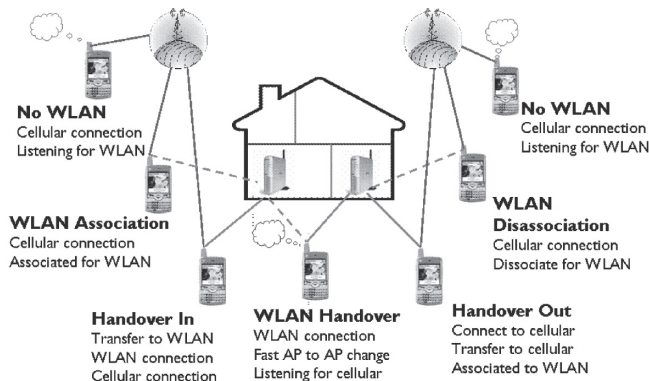


Fig. 4 Compounding the wireless LAN terminals.

area using the Wi-Fi technology alone. In addition, its stability is weaker than with other communication systems, as may be seen with the vulnerability to interference due to the disorderly placement of access points or the presence of other communication equipment and the tendency of QoS degradation due to the distributed access method proper to Wi-Fi.

New standards have been established to solve the stability problems accompanying Wi-Fi, such as the 802.11e standard for QoS improvement. However, these standards are classified as option standards from the viewpoint of compatibility with the already widely deployed equipment and it is still hard to achieve perfect stability with Wi-Fi alone. Therefore, to implement a next-generation network that is convenient and stable, it will be effective to apply the multi-homing sys-

tem. This method utilizes wide area advantages and the convenience of Wi-Fi at maximum but in case of a problem such as interference, it switches Wi-Fi to another bearer instantaneously in order to secure stability of communications.

Since the main function of combination is to compensate for the weak points of Wi-Fi, it is essential that the bearer takes the license band and adopts a strong QoS function. The currently available communication technologies that meet these conditions are the mobile (3G) and WiMAX but, considering the affinity with IP and the possibility of advanced linkage operations such as uninterrupted handover, the optimum solution may be to adopt multi-homing based on linkage with WiMAX.

Specifically, a service area in which both the Wi-Fi and WiMAX access systems are available is formed by handling the BS of WiMAX and the Wi-Fi access points in the reachable range of its radio waves as a single group as shown in Fig. 5. When interference or signal degradation is detected in the Wi-Fi system in this area, the mutual linkage between Wi-Fi and WiMAX allows Wi-Fi to be switched immediately to WiMAX so that the stability of the service area is secure.

4. Conclusion

The means of wireless access, such as the mobile phone and wireless LAN now provide an indispensable means of communication for our daily lives. In the future, too, these systems will be subject to requirements for improving network and ter-

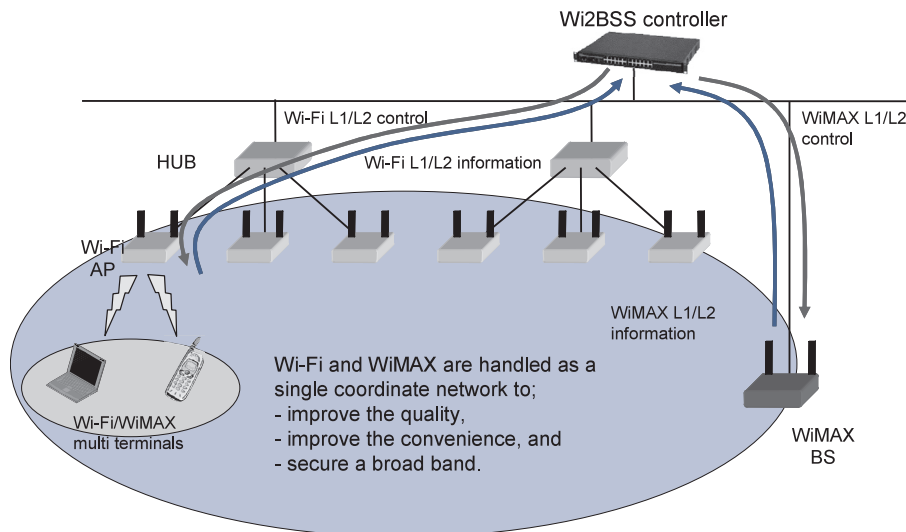


Fig. 5 Wi-Fi/WiMAX linkage.

minimal stability as life-support lines and for improving the convenience of meeting our various needs.

In this paper, we introduced technologies for improving the dependability of next-generation mobile communications.

At NEC, we aim to contribute positively to activities for the standardization of the individual technologies introduced above and to help establish a safe and secure ubiquitous information society. Moreover, it is our intension to continue to provide solutions for next-generation mobile communications in order to supplement the large number of technologies that we already have available.

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