

Next-generation Wireless Broadband Systems

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OVERVIEW: As mobile communication services become more ubiquitous and subject to greater demands, a shift in emphasis from voice calls to data communications is taking place and commercialization has already started for the next generation of wireless broadband with system bandwidths of 10 MHz or more. Two technologies that have gained particular attention amidst this transformation are Mobile WiMAX and LTE. Hitachi has participated in the various standards organizations working on Mobile WiMAX and LTE from the beginning and has been working on the development of base stations, gateways, and other equipment to develop the key products required to position itself as a wireless broadband system vendor. Work is also underway on achieving an early implementation of the IMT-Advanced generation-after-next wireless broadband system.

INTRODUCTION

IN the field of mobile communications, the move toward the next generation of wireless broadband systems is already underway.

With the growth in the ubiquity of mobile communication services and the increasing demands being placed on these services, the emphasis is shifting from voice calls to data communications. The distribution of a wide range of mobile content including mail, music, games, standby applications, and navigation has become an integral part of our way of life and the demand for mobile commerce such as mail order, ticketing, and auctions is growing year after year. There is no telling how far the growing need for services such as file transfer, video streaming, and games will push the demand for broadband communications. Also, support for a diverse range of applications has led to QoS (quality of service) becoming an important technical issue. Against this background, commercialization of next-generation wireless broadband systems with a system bandwidth of 10 MHz or more is now underway.

This article describes the features of the new Mobile WiMAX^{*1} (World Interoperability for Microwave Access) and LTE (Long Term Evolution) wireless standards, Hitachi's involvement, and progress toward IMT-Advanced (International Mobile Telecommunication—Advanced).

*1 WiMAX and WiMAX Forum are registered trademarks of the WiMAX Forum.

*2 Theoretical value. Varies depending on the system profile, radio conditions, and other factors.

MOBILE WiMAX

Mobile WiMAX has attracted attention internationally as a next-generation mobile broadband system. Mobile WiMAX is a technology defined by The Institute of Electrical and Electronics Engineers, Inc. (IEEE) standards organization and the WiMAX Forum^{*1} that provides high-speed data communications over a 10-MHz bandwidth with a maximum uplink speed of 10 Mbit/s and downlink speed of 40 Mbit/s^{*2}.

Hitachi has participated in these standards organizations from the beginning and has been working on the development of base stations, gateways, and other key products (see Fig. 1).

Fig. 2 shows an overview of a Mobile WiMAX system. The Mobile WiMAX system uses base stations and an ASN-GW (access service network gateway) to manage the wireless operation, location, and movement



Fig. 1—ER3000 Series WiMAX Products.
A WiMAX base station and ASN-GW are shown.

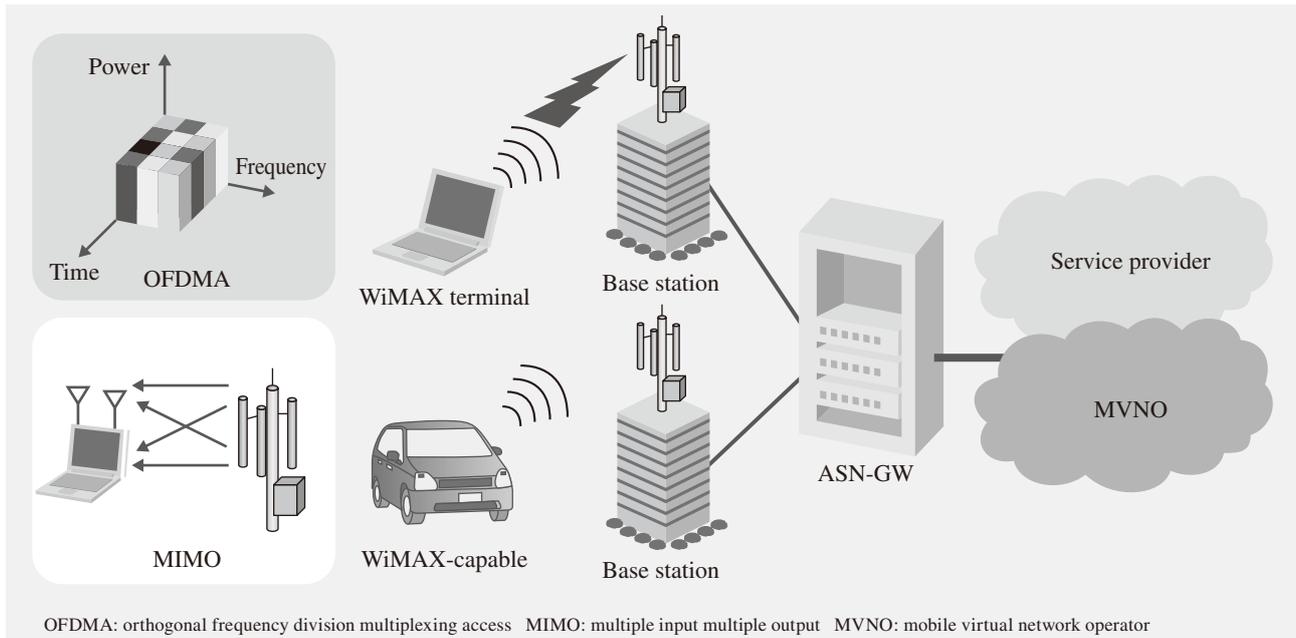


Fig. 2—Overview of Mobile WiMAX System.

The Mobile WiMAX system uses the next generation of high-speed technologies (OFDMA and MIMO) to provide the mobile Internet with high-speed data communications.

of WiMAX terminals. It uses OFDMA (orthogonal frequency division multiplexing access) and MIMO (multiple input multiple output) technologies to achieve high-speed communications.

OFDMA is a data transmission method that can maintain high-speed communications in a poor radio environment by splitting the transmission of a high-speed data stream into separate low-speed data streams that have a high tolerance for propagation delays and are sent in parallel via multiple frequencies.

MIMO is a signal processing technique that significantly improves transmission efficiency by using a number of antennas to send simultaneous multiplexed transmissions of multiple data and, at the receiving end, uses a technique similar to the solving of simultaneous equations to extract the transmitted data. Although the technique is already used in wireless LANs (local area networks) in stable environments such as indoors, Mobile WiMAX is the first time it has been put to use in a dynamic outdoor environment.

Broadband has become established in homes and offices in recent years, giving many people easy access to information and other rich content on the Internet. The arrival of Mobile WiMAX will provide this same broadband environment in a way that is no longer dependent on where you are, indoors or out. Notebook PCs (personal computers) with WiMAX communication modules fitted as standard features are already on the market, enabling broadband

Internet access from anywhere without requiring the installation of a special communications card. It is anticipated that WiMAX communication modules will be used in a wide range of different fields and will help facilitate the spread of intelligent home appliances and new infrastructure services.

Another aspect of Mobile WiMAX that has attracted attention is the emergence of virtual mobile service operators known as MVNOs (mobile virtual network operators). These are operators who do not have their own licenses for wireless communication services and instead use the Mobile WiMAX infrastructure to operate distinctive mobile broadband service businesses. It is expected that services will become even more diverse in the future and that international roaming technology will allow users travelling overseas to access the same broadband environment they have in Japan.

LTE

LTE^{(1), (2)} was developed by the 3GPP (3rd Generation Partnership Project) standards organization as a generation 3.9 mobile communication system that provides advanced features on mobile phones such as W-CDMA (wideband code division multiple access) and EV-DO (evolution data only) [referred to in the standard as HRPD (high rate packet data)]. A large number of operators have announced that they will adopt LTE.

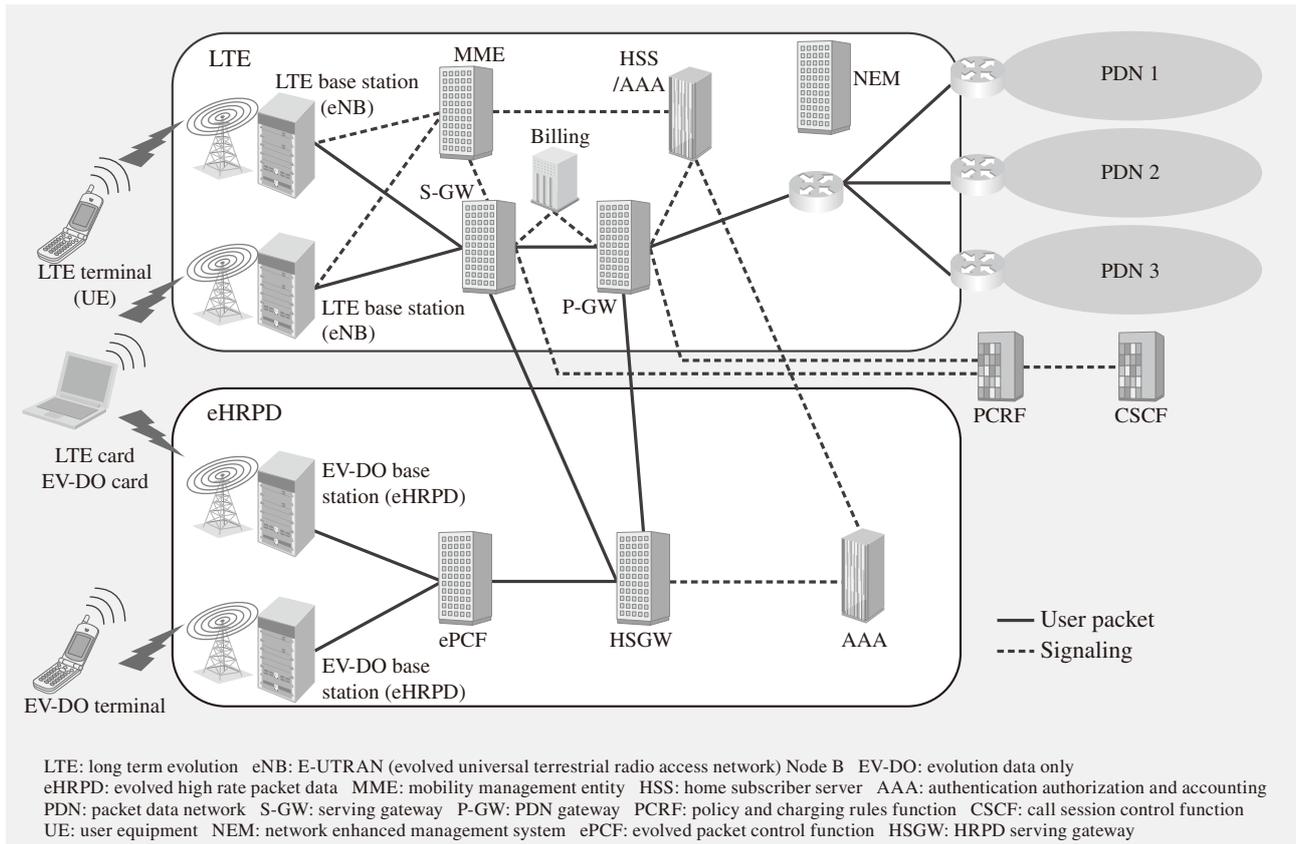


Fig. 3—Overview of LTE System.

The LTE system has a flat structure to achieve short delay times and open interfaces that allow connection to numerous other networks.

Like Mobile WiMAX, LTE utilizes technologies such as OFDMA and MIMO and enables high-speed data communications using two 10-MHz bands \times 2 MIMO with an uplink speed of 37 Mbit/s and downlink speed of 73 Mbit/s^{*3}. This is significantly faster than EV-DO which has an uplink speed of 1.8 Mbit/s and downlink speed of 3.1 Mbit/s over a 1.25-MHz bandwidth. Accordingly, it makes possible services such as the transfer of large files and high-resolution video streaming that were impractical in the past.

Fig. 3 shows an LTE network. The LTE gateway is split into an S-GW (serving gateway) and P-GW (packet data network gateway). The P-GW incorporates standard functions whereby it operates as the mobile IP (Internet protocol) HA (home agent) that links the access network to the PDN (packet data network) that provides services. Accordingly, the P-GW can be connected to a range of different wireless access gateways including the HSGW (HRPD serving

gateway) for EV-DO and the PDIF (packet data interworking function) for wireless LANs, for example. It also allows the use of different wireless access methods to augment coverage by combining more than one type of wireless access.

In LTE, user data is exchanged directly between the S-GW and base station [eNB: E-UTRAN (evolved universal terrestrial radio access network) Node B] so that, unlike the PCF (packet control function) of EV-DO, there are no intermediary nodes and the number of hierarchy levels is low. Combined with other techniques, it can achieve delay times of 5 ms or less. This is fast enough for applications such as multi-player action games and other interactive services. LTE also allows the UE (user equipment) to connect simultaneously to multiple PDNs that provide different services. For example, it is possible to have a service configuration in which a VoIP (voice over Internet protocol) connection to PDN1 is maintained at the same time as an FTP (file transfer protocol) connection to PDN2 and an Internet connection to PDN3. The MME (mobility measurement entity) handles functions such as paging when the terminal receives a message

*3 Theoretical value. Varies depending on the radio conditions and other factors.

and handover between base stations when the terminal moves from one place to another. The PCRF (policy and charging rules function) sends policies and charging rules to the gateway so that the gateway can handle QoS and other policy control along with billing. The NEM (network enhanced management system) performs monitoring and control of the equipment that makes up the LTE system.

As existing wireless access and other services are kept when LTE is introduced, these need to be migrated to the LTE system. The 3GPP, 3GPP2, and other standards organizations are working on standardizing eHRPD (evolved HRPD) which adds new functions to allow interworking with LTE without requiring changes to the EV-DO wireless specifications.

As an LTE vendor, Hitachi has developed key products (see Fig. 4).

Hitachi is also working on initiatives that include ensuring the continuity of billing and authentication techniques and high-speed handover between LTE and eHRPD systems.



Fig. 4—ER5000 Series LTE Products.
Core network equipment is shown.

WORK TOWARD FURTHER PROGRESS

In February 2008, the ITU-R (International Telecommunication Union Radiocommunication Sector) issued a request to the standards organizations to submit candidate standards for the generation-after-next IMT-Advanced wireless broadband system. In response, the IEEE is working on standardizing the IEEE802.16m successor of Mobile WiMAX and the 3GPP is working on the LTE-Advanced successor of LTE with the aim of meeting the February 2011 target for completing the ITU-R wireless interface standard recommendation.

IMT-Advanced aims to incorporate the following functional enhancements while giving consideration to maintaining backward compatibility with the Mobile WiMAX and LTE systems that will have been deployed by the time the new standard is introduced.

- (1) Increased frequency utilization efficiency [bit rate for each 1 Hz of bandwidth (bit/s/Hz)] by increasing the number of MIMO antennas
- (2) Increased maximum system bandwidth of 100 MHz (5 times that of LTE) with a maximum downlink speed of 1 Gbit/s (and 500-Mbit/s uplink speed)
- (3) Improved frequency utilization efficiency (1.5 to two times that of LTE) through use of a wireless interface that coordinates between relay stations, base stations, and other nodes

The combined effect expected from the above three functional enhancements is that the throughput experienced by the user will reach approximately 10 times that provided by LTE.

In addition to improving the quality of content such as streaming services that are already available, IMT-Advanced will also have adequate capacity to support services such as thin clients and cloud computing that require a guaranteed bandwidth in the Mbit/s range, for example. Anticipated applications include virtual reality in which not only audio and video but also tactile and other sensory information is transmitted.

As machine-to-machine communications between various different electric devices becomes more widespread, services that are unlike any types of service that have gone before will become possible, such as concierge services that support user activities by collecting all sorts of different information, and this is likely to increase even further the importance of the wireless communications infrastructure.

By initiatives such as making submissions to standards organizations and presenting the results of computer simulations, Hitachi is contributing to the early realization of IMT-Advanced and improvements in user service.

CONCLUSIONS

This article has described the features of Mobile WiMAX, LTE and other wireless standards, Hitachi's involvement, and progress toward IMT-Advanced.

Mobile communication is becoming an essential part of the social infrastructure in various different areas, including for individuals, households, vehicles, and businesses. The next-generation wireless broadband systems that represent the form that this progress is taking are giving birth to new types of business

such as MVNOs and the integration of multiple different wireless systems, and the provision of completely new types of service that rely on high-speed communications, short delay times, and other such features. Hitachi intends to continue contributing to establishing a full range of products and to advances in next-generation wireless broadband systems.

REFERENCES

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