Next-generation Broadband Wireless System

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OVERVIEW: Spearheading the next generation of broadband wireless systems, services based on a new wireless communications technology standard called WiMAX and the next-generation PHS are expected to become available in fiscal 2009. The introduction of WiMAX is also under review to bridge the digital divide in disadvantaged areas such as remote islands and mountainous regions. In developing a commercial system to support WiMAX's international standards and support the provision of advanced services such as MCBCS, Hitachi Group has actively worked on the improvement of next-generation broadband systems able to address domestic and foreign needs flexibly.

INTRODUCTION

AS optical fiber networks have become available to end users, the type of content being accessed on the Internet is changing away from text and image-oriented information towards high-volume data such as sound and video. At the same time, there is a growing trend towards the combined use of personal computers and mobile terminals (e.g. mobile phones) because using a mobile terminal on its own does not allow users full enjoyment of rich content services. These circumstances have heightened expectations that mobile broadband systems will provide fast Internet access in a mobile environment.

In a business context, an increasing number of people use thin-client personal computers outside the office as a way of protecting their personal data and other information assets. There is a growing demand for a mobile broadband system that provides fast data transfer and quick response.

The CDMA (code division multiple access) 2000 1xEV-DO (evolution data only) Revision A high-speed communications standard adopted in third generation mobile telecommunication systems can deliver up to 1.8 Mbits/s uplink and 3.1 Mbits/s downlink speeds using a bandwidth of 1.25 MHz, while the W-CDMA (wideband CDMA) high-speed communication standard provides up to 64–384 kbits/s uplink and 384 kbits/s downlink (when the user is walking or stationary, 2 Mbits/s when the user is stationary) speeds using a bandwidth of 5 MHz. Compared to this, the next generation of broadband wireless systems can provide communication speeds

TABLE 1. Mobile Broadband Systems and Communication Speed
The communication speed of the next generation of mobile broadband systems is ten to a hundred times faster than third generation mobile telecommunication systems.

Scheme	EV-DO Revision A	W-CDMA	HSDPA	WiMAX	LTE	UMB
Multiplexing	CDMA	CDMA	CDMA	OFDMA	OFDMA	OFDMA
Communications	FDD	FDD	FDD	TDD/FDD	TDD/FDD	TDD/FDD
Bandwidth	1.25 MHz	5 MHz	5 MHz	20 MHz	20 MHz	20 MHz
Uplink speed (max.)	1.8 Mbits/s	64–384 kbits/s	384 kbits/s	75 Mbits/s	50 Mbits/s or higher	50 Mbits/s or higher
Downlink speed (max.)	3.1 Mbits/s	384 kbits/s (2 Mbits/s)	14.4 Mbits/s	75 Mbits/s	100 Mbits/s or higher	288 Mbits/s or higher
Application	Real-time multimedia communications	Circuit-switching packet communications	High-speed data download	High-speed data communications	High-speed data communications	High-speed data communications

W-CDMA: wideband code division multiple access
HSDPA: high speed downlink packet access
CDMA: code division multiple access
OFDMA: orthogonal frequency division multiple access
FDD: frequency division duplex
TDD: time division duplex

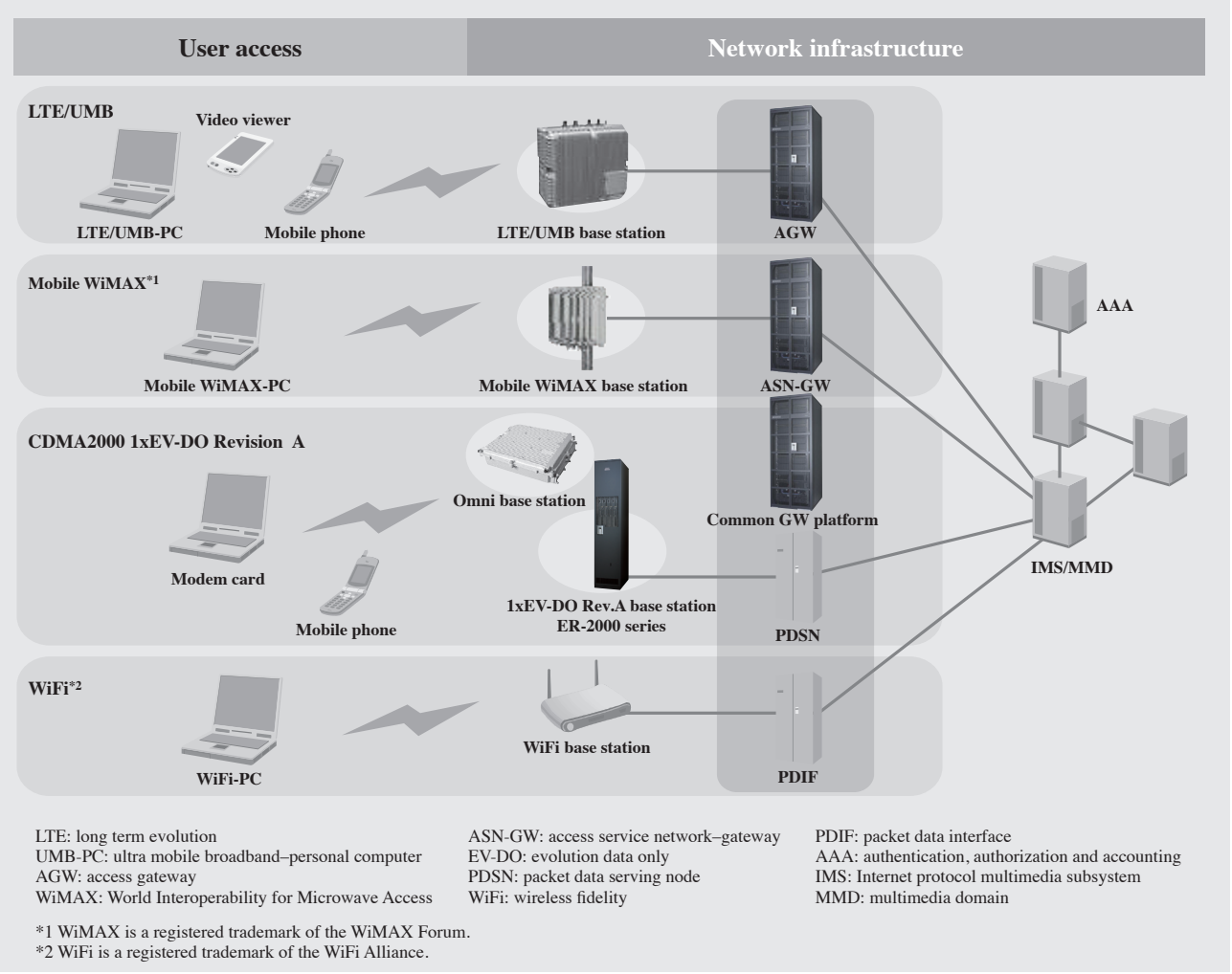

Fig. 1—Hitachi's Mobile Access Network.
The network equipment technologies developed for WiFi and EV-DO are utilized to develop network equipment for the next generation of broadband wireless access systems (WiMAX, LTE, and UMB).

that are ten to a hundred times faster (see Table 1).

This article outlines Hitachi Group's efforts in the field of next-generation broadband wireless systems that are currently under development and describes the system configuration and hardware/software characteristics of a Mobile WiMAX System that is expected to be launched as a commercial service by the end of fiscal 2009 (see Fig.1).

WIRELESS BROADBAND REQUIREMENTS

Schemes to provide the next generation of wireless broadband are roughly divided into two groups: systems that have evolved from the mobile telecommunications system and systems that have evolved from wireless LANs (local area networks). The former group are called 3.9 generation mobile communication systems to contrast them with third generation telecommunication systems. This group includes LTE (long term evolution), a faster version of W-CDMA with a transfer rate of 100 Mbits/s or faster for downlink and 50 Mbits/s or faster for uplink, and UMB (ultra mobile broadband), a standard that has evolved from CDMA2000 and has a transfer rate of 288 Mbits/s or faster for downlink and 75 Mbits/s or faster for uplink. Similarly, the latter group are called the 3.5 generation and include WiMAX (World Interoperability for Microwave Access) which has a transfer rate of up to approximately 75 Mbits/s using a bandwidth of 20 MHz.

In Japan, the 2.5 GHz band was allocated for use by mobile broadband wireless access systems to accommodate the future demands of the ubiquitous network society. UQ Communications[*1] using WiMAX and WILLCOM[*2] using a next-generation PHS (personal handyphone system) scheme had

plans approved in December 2007 to install specified base stations for nationwide mobile communications services, each with a bandwidth allocation of 30 MHz. System installation is underway with the aim of launching the services in fiscal 2009. Meanwhile, the 10 MHz regional band for fixed communication services is scheduled to be progressively allocated from 2008 summer with services expected to commence during the subsequent six months.

Although a number of foreign nations have already conducted technical demonstrations of WiMAX, Japan will become the first country to start a practical mobile WiMAX service, and needs to build the system in the limited period of time available before the service is due to be launched.

EFFORTS ON STANDARDIZATION AND INTEROPERABILITY

The IEEE (Institute of Electrical and Electronics Engineers, Inc.) and the WiMAX Forum (having approximately 530 company members around the world as of March 2008) have promoted the standardization of WiMAX to ensure the interoperability of products certified as complying with the standard. This makes it easier to spread the task of system implementation across a number of manufacturers.

Hitachi Group has worked on the development of gateway equipment for the Mobile WiMAX System and the integrated operation and maintenance center for the overall ASN (access service network) consisting of base stations and gateway equipment in accordance with the standards based on its past development experience in access systems for 1xEV-DO and fixed communications in order to meet the needs of system implementation in a short time. As an example of its active efforts, interoperability testing facilities have been introduced within Hitachi Group to verify interoperability with equipment from other manufacturers in a limited period of time.

MOBILE WiMAX SYSTEM

The Mobile WiMAX System mainly consists of ASN and CSN (connectivity service network) that includes AAA (authentication, authorization and accounting) (see Fig. 2). The functional division of the ASN is specified via three profiles and Hitachi Group has adopted Profile C which specifies an integrated ASN in which the base stations and ASN-GW are separate. The major characteristics include (1) handover control is performed by the base stations, (2) radio resource control and management is handled within the base stations, and (3) mobility management for mobile terminals (e.g. mobile phones) is performed using the R4/R6 interface which is specified as the mobility management protocol in the ASN.

Base Stations Characteristics

Hitachi Communication Technologies, Ltd. has worked on the development of a mobile WiMAX macro base station to provide a competitive base station for Japanese and world markets based on Hitachi Group's past experience in mobile communications including mobile station management technology.

The mobile WiMAX macro base station currently under development uses two 10 MHz bands (10 W output each) and provides all base station functions in a single box that weighs 20 kg and is 20 L in volume (target value). This compact base station facilitates installation and can be expanded by connecting multiple additional base station units in a chain-like manner according to the traffic load. The multiplexing scheme used by the base station is OFDMA (orthogonal frequency division multiple

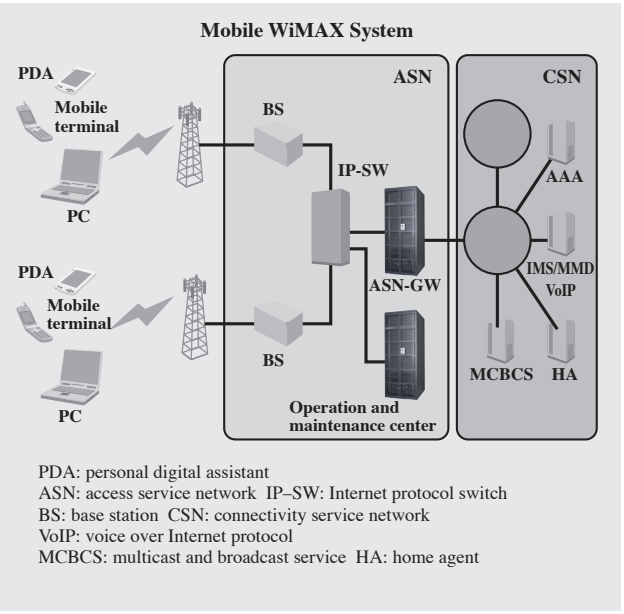

Fig. 2—Example WiMAX Network Configuration.
Interfaces to ensure interoperability are specified for various terminals (MS), ASN, and CSN components. Interoperability between BSs and ASN-GWs is specified by the R6 interface.

*1 UQ Communications is a registered trademark of UQ Communications Inc.
*2 WILLCOM is a registered trademark of WILLCOM, Inc.

access), which is commonly adopted in future next-generation wireless broadband including LTE and UMB. This scheme typically has higher power consumption as it needs to operate with a sufficient margin from the output saturation point due to the linearity of the amplifier and this is likely to have an impact on transmission characteristics. To deal with this problem, high-gain amplifiers, digital pre-distortion, and a technique that lowers the peak-to-average power ratio are adopted. This results in lower power consumption, which is a requirement in terms of global environmental protection.

As the uplink from the terminal is the dominant factor in designing the base station coverage, the required number of base stations can be reduced by the enhanced radio performance which expands the cell radius. This is achieved by improving the diversity gain through the use of multiple antennas equipped with two channels each for reception and transmission. This reduction in the number of base stations is expected to reduce system installation costs.

Furthermore, in an effort to improve the spectrum efficiency, the radio link capacity has been expanded by introducing a multi-scheduling function and advanced technologies such as Adaptive MIMO (multi-input multi-output) Switching (Matrix A/B) which switches between using the space time coding MIMO technique and spatial multiplexing depending on the link quality, and by using techniques such as FFR (fractional frequency reuse) to minimize interference between neighbor base stations.

ASN-GW Characteristics

Hitachi Group is developing an ASN-GW (gateway) for mobile WiMAX and a GW for LTE/UMB on a common platform based on the group's past development experience in mobile gateway equipment such as PDSN (packet data serving node), an IP(Internet protocol) packet terminal developed for the CDMA2000 1xEV-DO system. It is easy to sustain operability as sequential support of the next generation of broadband wireless systems is possible simply by replacing the system-specific software. In addition, Hitachi can develop software such as radio management functions in a short period of time by taking advantage of its past development experience and know-how.

By adopting methods that separate call process control (C-Plane) from the bearer process (U-Plane) that makes the imaginary connection established between radio segments, Hitachi has chosen a hardware configuration optimized for each plane in the ASN-GW. With this configuration, hardware can be configured in a flexible manner according to the traffic needs ranging from the small capacity of the regional band to the large capacity of the national band (see Fig.3).

The multicore CPU (central processing unit) with low power consumption adopted for the U-Plane enables high-speed processing that is at least 10 times faster than the processing capacity of conventional mobile gateway units.

As the C-Plane software inherits know-how from existing equipment such as the PMIP (proxy-mobile IP) system that processes mobile IP, the RADIUS (remote authentication dial in user service) protocol for certification, accounting and operation monitoring systems for network equipment, a shortened development period is achieved. Better software stability is also accomplished by using an open platform. The U-Plane software inherits the GRE (generic routing encapsulation) protocol for tunneling from existing equipment and the IP-in-IP encapsulation/decapsulation software technology, and also supports multicore processing.

MCBCS

Based on its past experience in development for CDMA2000 1xEV-DO Revision A, Hitachi Group has worked on the development of an ASN-GW and MCBCS (multicast and broadcast services)

Fig. 3— ASN-GW for Mobile WiMAX.
Can be reconfigured flexibly depending on the traffic.

server for MCBCS, a function for simultaneously distributing data via mobile WiMAX.

In order to distribute program data to multiple users simultaneously, the MCBCS server multicasts program data to multiple ASN-GWs, which in turn multicast the program data received from the MCBCS server to multiple base stations, allowing the distribution of a set of program data to multiple wireless service areas. In addition, radio resource usage can be reduced in wireless service areas by having mobile terminals (e.g. mobile phones) share a single connection.

Furthermore, from the perspective of content distribution, a function to dynamically change the areas for distribution on an hourly basis is available.

CONCLUSIONS

This article has given an overview of the WiMAX system under development by Hitachi Group and its hardware and software characteristics.

Leveraging its accumulated technologies and experience, Hitachi Group will continue to contribute to the further development of mobile telecommunications.

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