1xEV-DO Revision A System to Realize Wireless Broadband Communications

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OVERVIEW: 1xEV-DO Revision A is a cell phone system that achieves high-speed data transmission of up to 3.1 Mbit/s on the downlink, and up to 1.8 Mbit/s on the uplink using the same frequency band as existing 1xEV-DO (1.25 MHz). It is worthy of being called a pioneering wireless broadband technology. To realize advanced services such as the video telephony, the Hitachi Group has applied that technology to build a commercial system. To cope with diversification in wireless broadband services, standardization organizations have been studying various next-generation wireless access systems, and Hitachi, too, is harnessing the strength of the Group to aggressively take up the challenge of mobile communication development.

INTRODUCTION

AS the use of cell phones spreads, there is a rising call for the use of cellular mobile terminals for services such as mail, Internet access, music and video distribution from anywhere within an area. In response to that demand, the 3GPP2 (3rd Generation Partnership Project 2) international specification organization has set the standard called 1xEV-DO (1x evolution-data only) Release 0 (referred to as EV-DO Rel. 0 below), which is based on wireless packet communication technology for cell phone systems that was developed by Qualcomm, Inc. of the U.S.

Since November 2003, the EV-DO Rel. 0 access point developed by Hitachi has been used as the access point for the KDDI Corporation's CDMA 1X WIN*1 service. That service has received high evaluation because it allows stress-free use of EZ Chaku-uta Full*2 and other rich content.

After that, to cope with an even greater diversity in applications, 1xEV-DO Revision A (referred to as EV-DO Rev. A below) was standardized to extend the functions of EV-DO Rel. 0. EV-DO Rev. A greatly improved the maximum transmission speed compared to the previous EV-DO Rel. 0, and achieved a system that is suitable for two-way real-time communication with the IP (Internet protocol) by strengthening the QoS (quality of service) function to allow packet

*1 CDMA 1X WIN is a registered trademark of the KDDI Corporation.
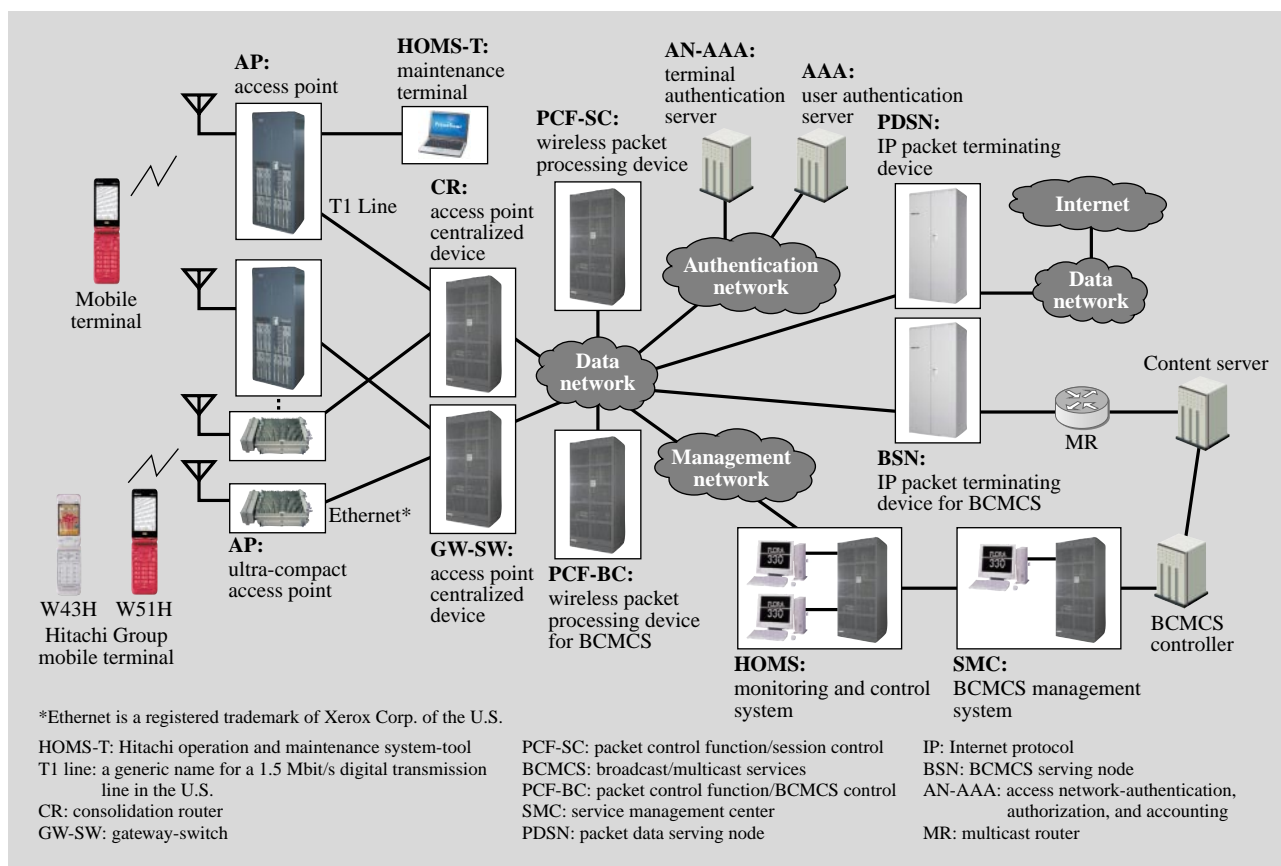*2 Chaku-uta Full is a registered trademark of the Sony Music Entertainment Inc.

communication delay control. Since December 2006, KDDI has been deploying EV-DO Rev. A as the infrastructure of a broadband mobile network that can provide all-IP services such as video telephony that uses VoIP (Voice over IP, a technology for sending and receiving voice data over the Internet or other IP network).

Here, we describe Hitachi's configuration of the newly-developed EV-DO Rev. A system, the hardware and software features, and conversion of the wireless access links to broadband (see Fig. 1).

EV-DO REV. A SYSTEM EXTENSIONS

EV-DO Rev. A has the following functional and performance extensions relative to the previous EV-DO Rel. 0.

(1) Higher maximum transmission speed

A maximum downlink transmission speed of 3.1 Mbit/s and a maximum uplink transmission speed of 1.8 Mbit/s are achieved using the same 1.25 MHz bandwidth as EV-DO Rel. 0. For the uplink, in particular, QPSK (quadrature phase shift keying) and 8PSK (8-phase shift keying) multiplexing have been added to the conventional BPSK (binary phase shift keying) method. Furthermore, the hybrid-ARQ (automatic repeat request) technique is applied to the uplink as well as the downlink, thus greatly increasing both the maximum transmission speed and the sector throughput.

(2) Strengthening the QoS function

Fig. 1—Configuration of the 1xEV-DO Revision A System.
With 1xEV-DO (1x evolution-data only) Revision A, the maximum sector throughput is 1.8 Mbit/s for the
uplink (from a mobile terminal to the access point) and 3.1 Mbit/s for the downlink (from an access point to a
mobile terminal), thus providing clearly faster data communication environment for wireless communication
system access than the original 1xEV-DO Release 0.

Greatly strengthening the QoS function allows provision of high-quality multimedia communication services in real time, which is not possible with EV-DO Rel. 0. Specifically, a QoS scheduler that recognizes constant throughput and low-latency applications is used on the downlink in addition to the previous best-effort service. Furthermore, rather than the probability-based transmission rate control method that was used for the uplink, a data channel power allocation method that allows a finer rate control is adopted to make it possible to maintain a constant quality, regardless of the radio environment or the number of connected calls (see Fig. 2).

(3) Faster call connection and disconnection

We greatly reduced the time required for call connection and disconnection by simplifying the connect and disconnect sequences. Doing so reduced the wait time for dial-up connections, allowing application to transceiver-type services such as PoC
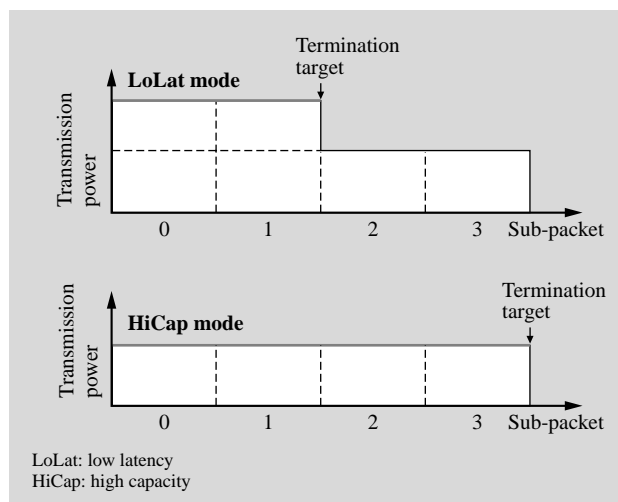

Fig. 2—Method of Allocating Power to Upward Packets.
With EV-DO Rev. A, the upward packets are divided into four sub-packets for transmission. Selection between the low-latency and high-capacity modes is accomplished by changing the allocation of transmission power.

(push to talk over cellular).

Hitachi's EV-DO Rev. A system makes the utmost use of the features of the EV-DO Rev. A standard, and by aiming for greatly increased processing power and accommodation density compared to the EV-DO Rel. 0 system, attains a great improvement in cost performance. Below we describe the special features of the devices that constitute Hitachi's EV-DO Rev. A system.

Access Point Features

The AP (access point) must meet various requirements such as amount of traffic that depend on where the device is installed, so we created a lineup of devices (see Fig. 3).

The new AP achieved high density and large capacity by using higher performance devices and higher mounting density compared with EV-DO Rel. 0. It also achieved high efficiency and low power consumption by applying DPD (digital predistortion) technology to the high-output amplifier.
(1) AP Type-II (high-capacity access point): This is a high-capacity type that can accommodate four times as many channels per unit as EV-DO Rel. 0. It is mainly used in metropolitan areas where traffic is concentrated. It can be installed in units of carrier and sector according to the traffic expansion and environmental conditions, and an entire 20-MHz band can be covered by using expansion units.
(2) AP Type-VI (ultra-compact access point): This is an omnicell-compatible ultra-compact access point. It is used mainly for supplementary access in enclosed areas such as tunnels and underground parking lots, etc., and in dead-spots such as building shadows. These devices can also be connected in a daisy chain.
(3) AP Type-III (compact access point, in development): This is a medium-scale device for use in areas intermediate between those for which Type-II and Type-VI are appropriate. It can accommodate twice as many channels per unit as an EV-DO Rel. 0 device.

Features of Center Devices

Communication center devices are installed centrally in a building called a central office. Each device concentrates multiple access points and performs monitoring and control. EV-DO Rev. A provides greatly improved processing power and higher capacity compared to EV-DO Rel. 0. The main features of these devices are described below.
(1) CR (consolidation router): This is a router that accommodates T1 lines. It can accommodate twice as

Fig. 3—Appearance of Each Type of Access Point.
Access point line-up to cope with various traffic conditions.

(a) High-capacity access point   **(b) Ultra-compact access point**

many T1 lines as an EV-DO Rel. 0 device.
(2) PCF-SC (packet control function/session control): This device passes data between AP and PDSN (packet data serving node) and has functions for session information management and terminal authentication, etc. It can manage at least three times the amount of session information as an EV-DO Rel. 0 device.
(3) PCF-BC (PCF-BCMCS control): This device has functions for packet data passing, soft combine control and other such functions for BCMCS (broadcast/multicast services).
(4) PDSN: This device has functions for the interface between an IP network and a RAN (radio access network), PPP (point-to-point protocol) termination, and charging and authentication in cooperation with AAA (authentication, authorization, and accounting).
(5) HOMS (Hitachi operation and maintenance system): This is a network monitoring and control system for RAN devices. It comprises a monitoring server and display system. One server can perform 2.5 times as much AP monitoring and control as an EV-DO Rel. 0 device.

FEATURED FUNCTION OF EV-DO REV. A SYSTEMS
Indispensable QoS Functions for Providing Advanced Services

Because of the strict demand on transfer delay in data communication services such as videophone, the QoS function has been strengthened in EV-DO Rev. A.
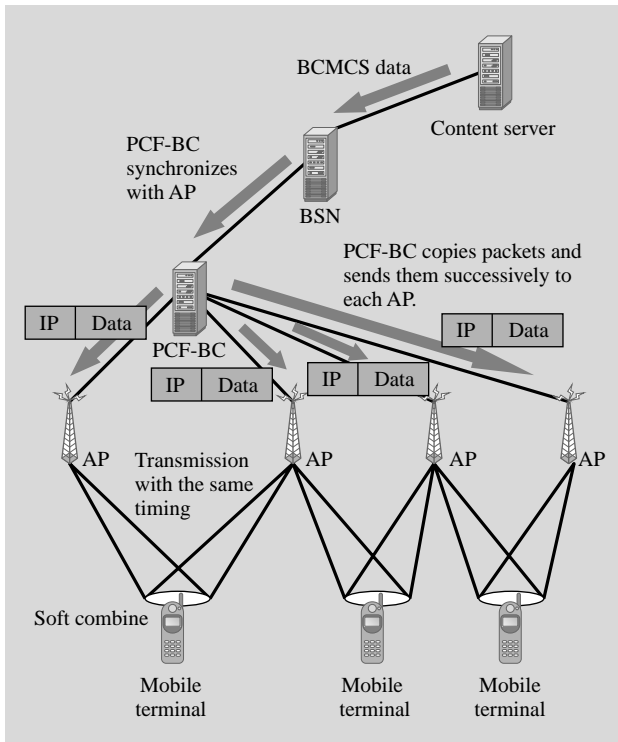
Fig. 4—*Soft Combine Function.*
Reception quality is improved by combining data received from multiple AP on the broadcasting channel.

The EV-DO Rev. A QoS functions include a priority control function that prioritizes packet transmitted on the radio uplink and downlink, and a connection control function for maintaining the radio bandwidth of mobile terminals that do not have a QoS function by controlling the number of QoS call connections. In addition, the connection control function is divided into two types, a connection limiting function and a quality control function that varies QoS call quality while the call is in progress.

Soft Combine Function for Implementing Broadcast-type Services

There exists BCMCS technology that is designed to achieve efficient radio frequency use by setting the number of broadcasting channels that can be received simultaneously by multiple mobile terminals. Near the edge of the cell, the radio signal from the AP is weak, so it is difficult to receive BCMCS data, but we developed a soft combine function that improves quality by combining the BCMCS data that is received on the broadcasting channel from multiple APs.

To implement the soft combine function, all of the APs must transmit the BCMCS data with the same timing, which requires synchronization of the PCF-
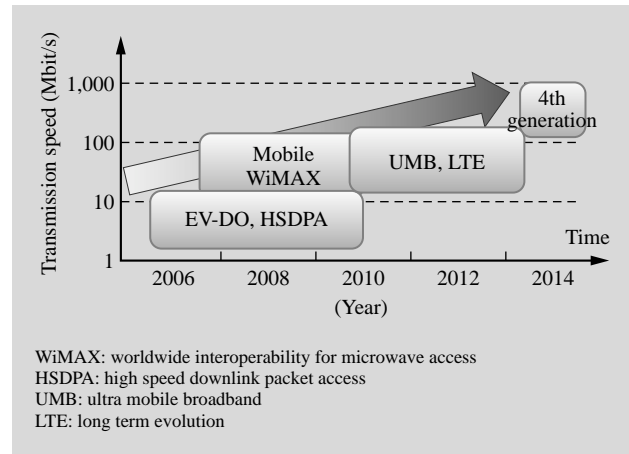

Fig. 5—*Roadmap for Next-generation Wireless Broadband System Development.*
To cope with diversification in wireless broadband services, standards organizations are studying next-generation radio access systems.

BC with the AP. The PCF-BC calculates the amount of data that can be transmitted in one cycle from the R-S (Reed-Solomon) coding and the BCMCS data transmission rate, and periodically divides the BCMCS data sent from the BSN (BCMCS serving node) into quantities that can be transmitted over the wireless link. It then appends the cycle number and the sequence number and transmits the data to each AP governed by the PCF-BC. The AP converts the BCMCS data received from the PCF-BC to the wireless format with the prescribed timing and then transmits it (see Fig. 4).

FURTHER WIRELESS BROADBAND DEVELOPMENT

With the recent diversification of wireless broadband services, the communication speed that is required of radio access continues to increase. To meet that demand, the next-generation radio access system is being studied by standards organizations, and systems that have OFDMA (orthogonal frequency division multiple access) and MIMO (multiple input multiple output) as features are being discussed (see Fig. 5).

The OFDMA method is robust against multi-path interference, allowing stable broadband signal transmission even in a mobile communication environment. MIMO, on the other hand, improves spectral efficiency by taking positive advantage of multiple propagation paths. Another special feature of the next-generation system is that specifications for low-latency are required to maintain the real-time

quality of services.

In the following sections, we describe the UMB (ultra mobile broadband), LTE (long term evolution), and mobile WiMAX (world-wide interoperability for microwave access) radio access systems that are being studied to meet the requirements described above.

UMB

UMB, which is being studied by 3GPP2, aims for transmission speeds of 68 Mbit/s for the uplink and 280 Mbit/s for the downlink with 4×4 MIMO. While UMB is based on OFDMA for both the uplink and downlink, the expandability of future services to efficiently handle the anticipated VoIP is secured by making part of the uplink resources available for CDMA (code division multiple access).

LTE

LTE is a system that targets transmission speeds of 100 Mbit/s downward and 50 Mbit/s upward when using 2×2 MIMO and is being studied in 3GPP. By using SC-FDMA (single carrier–frequency division

multiple access) for the uplink, LTE reduces the ratio of mean to peak signal power, thus reducing power consumption by the mobile terminal.

Mobile WiMAX

Mobile WiMAX is an access system that conforms to the IEEE 802.16e standard that was approved in December 2005. It achieves a maximum transmission speed of 75 Mbit/s in a 20-MHz bandwidth. The IEEE 802.16 Committee is continuing with standardization even now, and studies for increasing the range and throughput by using together with relay stations, and studies for increasing speed to achieve transmission at up to 1 Gbit/s are in progress.

CONCLUSIONS

We have described the extension, the hardware and the functional features of the 1xEV-DO Revision A system that has been developed by Hitachi. Making use of accumulated technology and experience, Hitachi will continue to contribute to the development of mobile communication into the future.

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