All-IP-based Mobile Communication Network

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OVERVIEW: In the field of mobile communication networks, services apart from voice (such as e-mail, Internet access, and music downloading) are expanding. As a result, "all-IP networks"—which can also provide voice-communication services on a network based on IPs—are being established. Research and development, as well as standardization activities concerning these all-IP networks, are therefore being pushed forward. Hitachi is investigating various capabilities required for transmission of voice on "all-IP-based mobile networks." One of these investigations involves testing on an EV-DO-standard test system implemented with a QoS function for averting increases in delay in voice transmissions.

INTRODUCTION

IN the field of mobile communications, in response to reduction of bit cost and demands for QoS (quality of service), the needs for broadband communication are getting respectively stronger. Under these circumstances, standardization work of voice transmission by high-speed wireless communication technology and IP (Internet Protocol) is being pushed forward by the 3GPP2 (3rd Generation Partnership Project 2) (see Fig. 1).

This report first describes standardization trends toward speeding up of wireless communication and integration of voice and data on an IP-network base, and then it presents evaluation results on QoS in voice transmission on the EV-DO (evolution-data only) standard.

TRENDS IN STANDARDIZATION OF NEXT-GENERATION WIRELESS TECHNOLOGY

High-speed Wireless Technology

In cellular wireless communication, CDMA (code division multiple access) technology—now in its third generation—is presently being enhanced. During the initial stages of this enhancement, with the appearance of 1xEV-DO, CDMA2000 (used in circuit-switching systems) was able to provide high-efficiency "best effort" data services. Furthermore, in the case of the next-generation version of 1xEV-DO (C.S0024 Revision A), a function called BCMCS (broadcast/multicast services), providing QoS and broadcast services, was incorporated (see Fig. 2). And in the "Revision B" version currently under standardization, one terminal can bundle together multiple bandwidths possessing the 1.25-MHz base bandwidth and transmit and receive signals simultaneously. As a result, peak rate is improved; for example, in the case of 3xEV-DO—which uses three bandwidths—a maximum transmission rate of 9.3 Mbit/s is made possible. In addition, as for the uplink and downlink bandwidths, more freedom of allocation is possible. For example, when the uplink line (from mobile terminal to base station) is 1xEV-DO, the downlink line (from base station to mobile terminal) by 3xEV-DO becomes possible, thereby allowing increased flexibility of the services provided.

Increased activity in regards to standardization of fourth-generation cellular wireless technology has started, and at WRC-07 (World Radiocommunication Conference 2007) of the ITU-R (International Telecommunication Union—Radiocommunication Sector), it is planned to determine the allocated carrier-frequency bandwidths for the fourth generation. At this time, systems providing data rates of 100 Mbit/s in motion, or a maximum of 1 Gbit/s while stationary, are being proposed, and as the modulation technique for these systems, OFDM (orthogonal frequency division multiplexing) is dominant.

Activities in advance of the fourth-generation technologies are also intensifying. That is, at the 3GPP (the standardization body for cellular wireless technologies), discussions on LTE (long-term evolution)—also known as "3.9G," where "G" stands

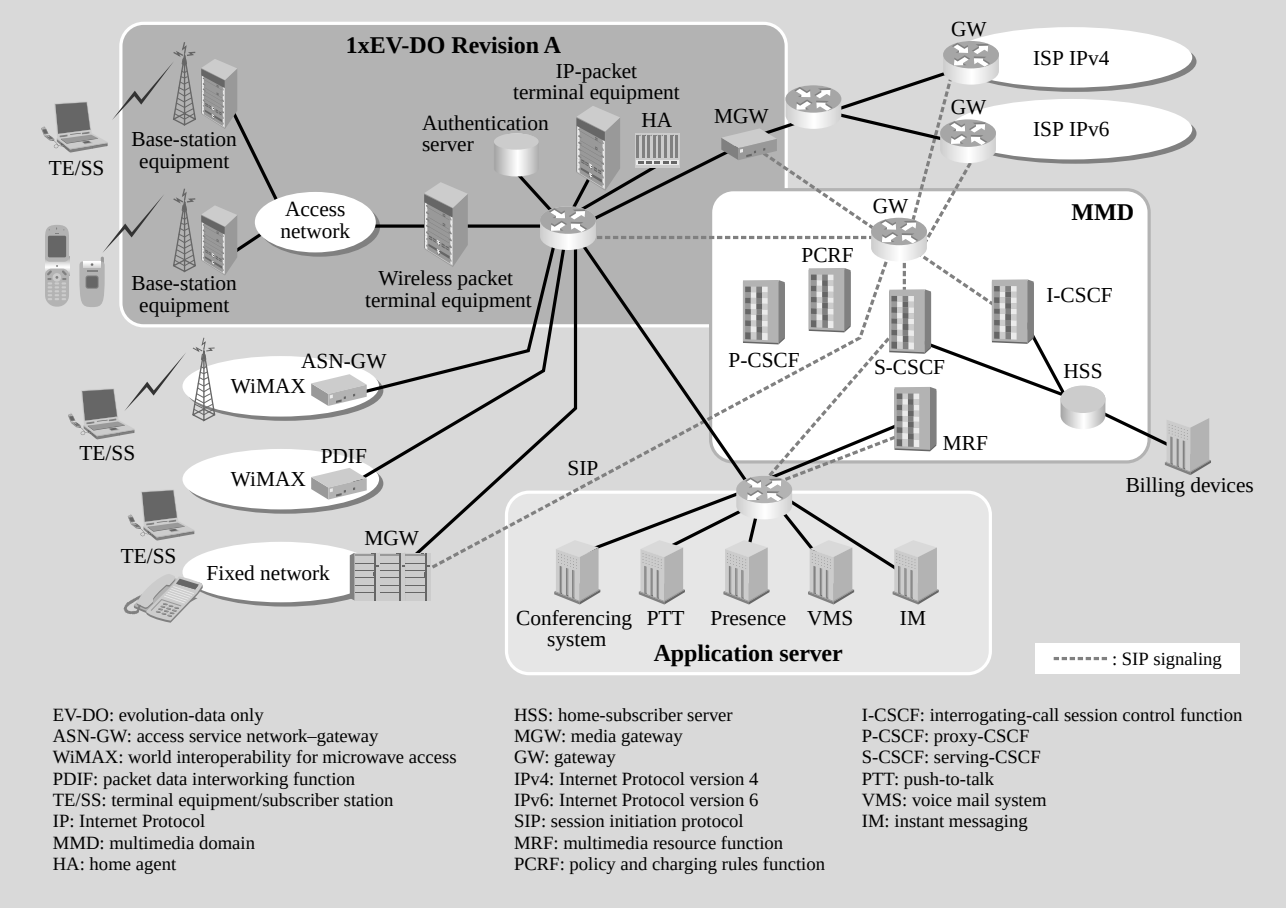


Fig. 1—Network-architecture Model of All-IP-based Mobile Communication Network.
Integration by IP of mobile communication network is being studied. Examples of the component parts of the network are shown.

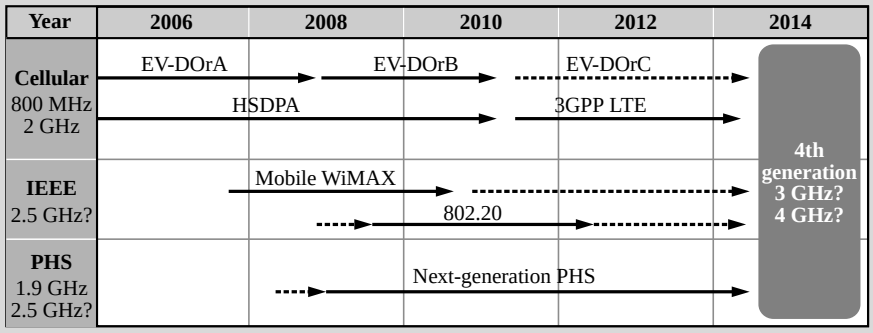


Fig. 2—Trends in Standardization of Mobile Networks.
Specification/standardization of cellular, IEEE system, and PHS are aimed at acquiring markets and frequency, and fierce competition is forecast.

for "generation"—have started. At present, investigations based on OFDM are being carried out, and emphasis is being placed on improving flexibility with regard to bandwidth and services. And 3GPP2 is investigating the Revision C standard at the same time.

Standardization activities of IEEE (The Institute of Electrical and Electronics Engineers, Inc.) are also vigorous. In particular, in IEEE802.16, the mobile version ("802.16e") was finalized in December 2005. Moreover, at the WiMAX (world interoperability for microwave access) Forum (a non-profit trade organization), profile and network standards for interconnectivity are being established. For building inexpensive systems, in WiMAX, it is considered that

services will become a local-selection type centered on urban areas and that their integration with cellular-wireless technology like 1xEV-DO will be important.

Multi-media Networks by IMS/MMD

To triumph against fierce competition from carriers, "all-IP" conversion of mobile-phone networks is being advocated as a strategy for providing good services at low cost. As part of this conversion, standardization of the IMS (IP multimedia subsystem)/MMD (multimedia domain) architecture as a system for integrating multimedia services based on IP networks is being pushed forward at 3GPP/3GPP2. In IMS/MMD, the SIP (session initiation protocol) is being adopted as a control protocol for multimedia sessions including voice. IMS/MMD is aimed at enabling easy and flexible connection of applications and services by providing a common service platform for wireless access systems such as 3G cellular, Wi-Fi (wireless fidelity), and WiMAX.

In accordance with the conversion of networks to IP standards by telecommunications carriers (which is continuing rapidly to not only mobile networks but fixed networks as well), IMS/MMD is also being adopted as the architecture for NGNs (next-generation networks)—whose specifications are under development at the ITU-T (ITU Telecommunication Standardization Sector). As for NGNs, IP packet networks with guaranteed QoS and security are being established, and networks that provide integration of services such as telephony, video conferencing, and data transmission are being targeted. Furthermore, application of IMS/MMD to services for integrating mobile and fixed services, so-called FMC (fixed-mobile convergence), is being investigated.

VOIP OVER EV-DO

Technologies for Achieving VoIP over EV-DO

1xEV-DO appeared as a "best effort" type of service. Consequently, since it is not fundamentally directed at voice transmission (which must meet strict conditions for delay characteristics), transmitting voice data on an EV-DO infrastructure requires implementation of QoS techniques. To realize QoS control on 1xEV-DO, a new evaluation formula, which takes delay amount as a parameter used in the scheduler for allocating lines for packets in the downlink, has been adopted, and a technique for prioritizing packets that require QoS has been introduced. Moreover, in regard to rate control for determining transmission rate of the wireless section on the uplink, changes are made to packets requiring QoS so that a constant rate can be easily maintained by priority.

On either the up- or downlink, line allocation and rate preservation for the QoS session are possible by priority.

Configuration of Experimental System

Hitachi has investigated the effect of implementing QoS into EV-DO systems. First, to confirm the QoS function, experimental testing was carried out. The testing system is shown schematically in Fig. 3. It is configured with an EV-DO system and the MMD system currently under development.

The MMD system consists of an SIP sever group termed a CSCF (call session control function) server for relaying SIP messages. In correspondence with the roles and configuration of the MMD system, the CSCF server is divided as P-CSCF (proxy CSCF), I-CSCF (interrogating CSCF), and S-CSCF (serving CSCF) servers.

SIP messages from all MSs (mobile stations) that initiate VoIP (voice over IP) communication go through the P-CSCF (i.e. the initial contact point). P-CSCF checks the validity of an SIP message sent from an MS and blocks any incorrect messages so that they are not sent to the MMD network. And when a QoS session is

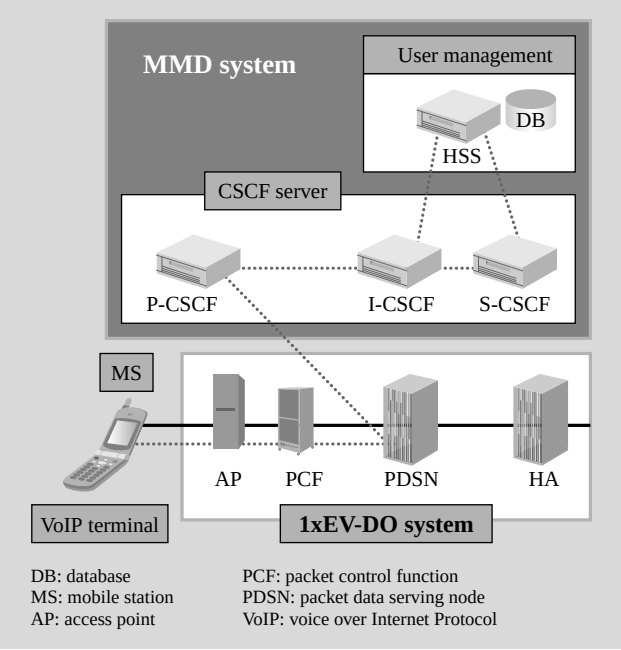
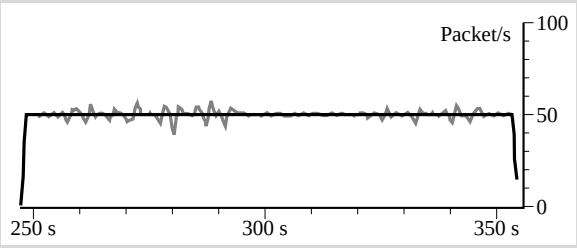
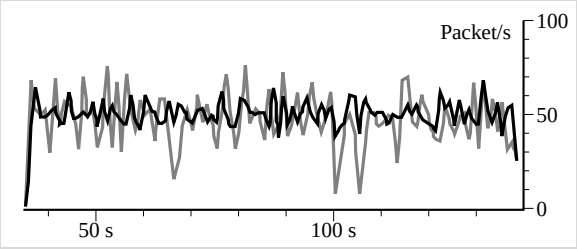


Fig. 3—MMD Testing Devices for Realizing VoIP over EV-DO. QoS (quality of service) control is packaged in the EV-DO standard, CSCF (which becomes a "soft switch") is combined, and an evaluation test for VoIP is configured.



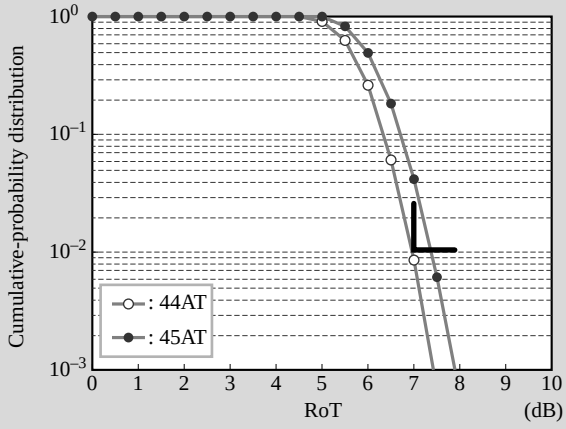
(a) With QoS



(b) Without QoS

Note 1: gray line (downlink); black line (uplink)

Fig. 4—Jitter Measurement Results from Evaluation-test System.
In the evaluation test, QoS control is switched on and off, and packet jitter is measured.



Note: 44AT (terminal number: 44 units/sector);
45AT (terminal number: 45 units/sector)
RoT: rise over thermal

Fig. 5—Circuit Capacity Seen from Limitation on Received Power (RoT) at Base Station.
According to the evaluation standard of 3GPP2, received power for stably operating a system is stipulated at a probability of exceeding 7 dB of below 1%. When the number of terminals increases, the curves deviate to the right, and overrun the right side of the L-shape, thereby reaching the limit of the specification.

set up, appropriate QoS information is sent to the PCRF (policy and charging rules function).

With a core SIP server for controlling the provision of services to users, the S-CSCF carries out routing of all SIP messages sent from the MS. Moreover, it performs user authorization based on information from an HSS (home-subscriber server) (mentioned later), and operates as a registrar for forwarding messages to the AS (application server) providing services.

When an SIP message is received from an external network, I-CSCF refers to the HSS according to the contents of that message; it then sends the message to the S-CSCF selected as a result of that inquiry. As well as that, it takes the role of concealing the configuration of the internal network from the external network. Moreover, HSS operates as a database storing service information and authentication information concerning users, and in response to enquiries from the CSCF server, it relays this information to the CSCF.

Evaluation Results on Delay Characteristic

Delay characteristic was evaluated on the above-described testing system, and the evaluation results are shown in Fig. 4. The vertical axis shows the transmission frequency of IP packets, whose variation expresses jitter. The black line represents the uplink line, and the gray line the downlink. In the case of no QoS control [see Fig. 4 (b)], it is clear that prominent jitter occurs on the downlink line. When QoS control [see Fig. 4 (a)] is executed, on the other hand, jitter is almost non-existent, demonstrating a good delay characteristic.

Evaluation Results on Terminal-reception Characteristics

To confirm the effectiveness of VoIP over EV-DO, terminal capacity was evaluated by simulation. The main factor determining handset capacity is gross received power of the base station involved in rate control of the uplink. The MS changes transmission power in response to the varying wireless-line state. However, by continuously raising power in order to maintain quality at all handsets, in the end, handsets within the cell boundary reach maximum transmission power, and the system goes into an unstable state. The point up to which the system can be stabilized and operated is specified in the evaluation standards of 3GPP2. That is, the probability that the RoT (rise over thermal) value (i.e. the ratio between received power at a base station and thermal noise) will exceed 7 dB should be less than 1%. The simulation results are shown in Fig. 5. In the figure, since the horizontal axis

is RoT, and the vertical axis is the cumulative probability distribution function of RoT , under this simulation condition, it is clear that the capacity is 44 handsets. Since this value exceeds the capacity of 35 units announced by the CDMA Development Group (CDG), it is clear that VoIP over EV-DO is an outstanding method, even given its limited bandwidth.

CONCLUSIONS

This paper described trends in standardization of wireless networks and reported evaluation results concerning voice transmission on an all-IP-based EV-DO network. Through its participation in 3GPP2, Hitachi will continue its efforts to expand the capability of the 1xEV-DO standard.

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