Broadcast Services and QoS Control Provided by 3rd-generation Mobile Communication Technology "1xEV-DO"

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OVERVIEW: The technical standards for attaining "BCMCS (broadcast and multicast services)" with accompanying guaranteed QoS levels on a 1xEV-DO 3rd-generation mobile communication system—providing wireless data transmission at a maximum rate of 2.4 Mbit/s—have been stipulated by the 3GPP2 standardization body. By adding this standardization to our already developed 1xEV-DO system, Hitachi has implemented BCMCS and QoS functions with its mobile telephony services. A trial 1xEV-DO system with these functions has been delivered to KDDI CORPORATION and tested under an experimental environment. With these additions of BCMCS and QoS functions, along with providing unicast transmission, this 1xEV-DO system is expected to provide services such as simultaneous data transmission and broadcasting as well as IP-videophone.

INTRODUCTION

WITH the popularization of mobile phones, the leading characteristic of voice communications is shifting from present fixed lines to wireless (radiowave) transmission. Moreover, the upgrading of fixed communication networks is having the synergistic effect of helping to spread mobile Internet environments. In response to the various needs created under these circumstances, the 3GPP2 (Third Generation Partnership Project 2) standardization body—under the guidance of QUALCOMM Incorporated in the U.S.—is proposing wireless packet-communication technologies for mobile phone systems. As a result of this standardization work, the 1xEV-DO (1x evolution-data only) standard has been stipulated. By applying specialized and optimized transmission methods to high-speed packet communication, with this standard, it is possible to increase the packet-transmission efficiency under a mobile environment and achieve a maximum transmission rate of 2.4 Mbit/s at a bandwidth of 1.25 MHz.

The 1xEV-DO standard is prescribed as a best-effort-type unicast transmission method (i.e., specification C.S0024 Revision 0). BCMCSs (broadband and multicast services) are established under the C.S0054 specification, and QoS (quality of service) is stipulated according to C.S0024 Revision A.

Hitachi has extended the capability of a 1xEV-DO system that it has already developed, and we verified its BCMCS and QoS functions under an experimental test environment (see Fig. 1). This system was introduced to KDDI CORPORATION on a trial basis.

As for providing BCMCS and attaining QoS, since technologies cover the radio-access part and the access network interface of a RAN (radio-access network), as well as the core network, all technologies—that is, from the lower layer to the upper layer—are required. Hitachi is participating in the technical-specification creation groups TSG-C, TSG-A, and TSG-X of the 3GPP2, making many contributions to 3GPP2, and contributing to implementation of these standardizations.

SERVICES UTILIZING BCMCS AND QoS

Services Utilizing BCMCS Functions

In regards to wireless communication systems, since radiowaves are a finite resource that must be shared, it is important to improve the utilization efficiency of the radio spectrum. This means that by implementing BCMCS, in the case that the same data is being sent to multiple users at the same time, it is possible to effectively utilize resources such as radiowaves and transmission equipment (see Fig. 2). It is considered that the types of services listed below

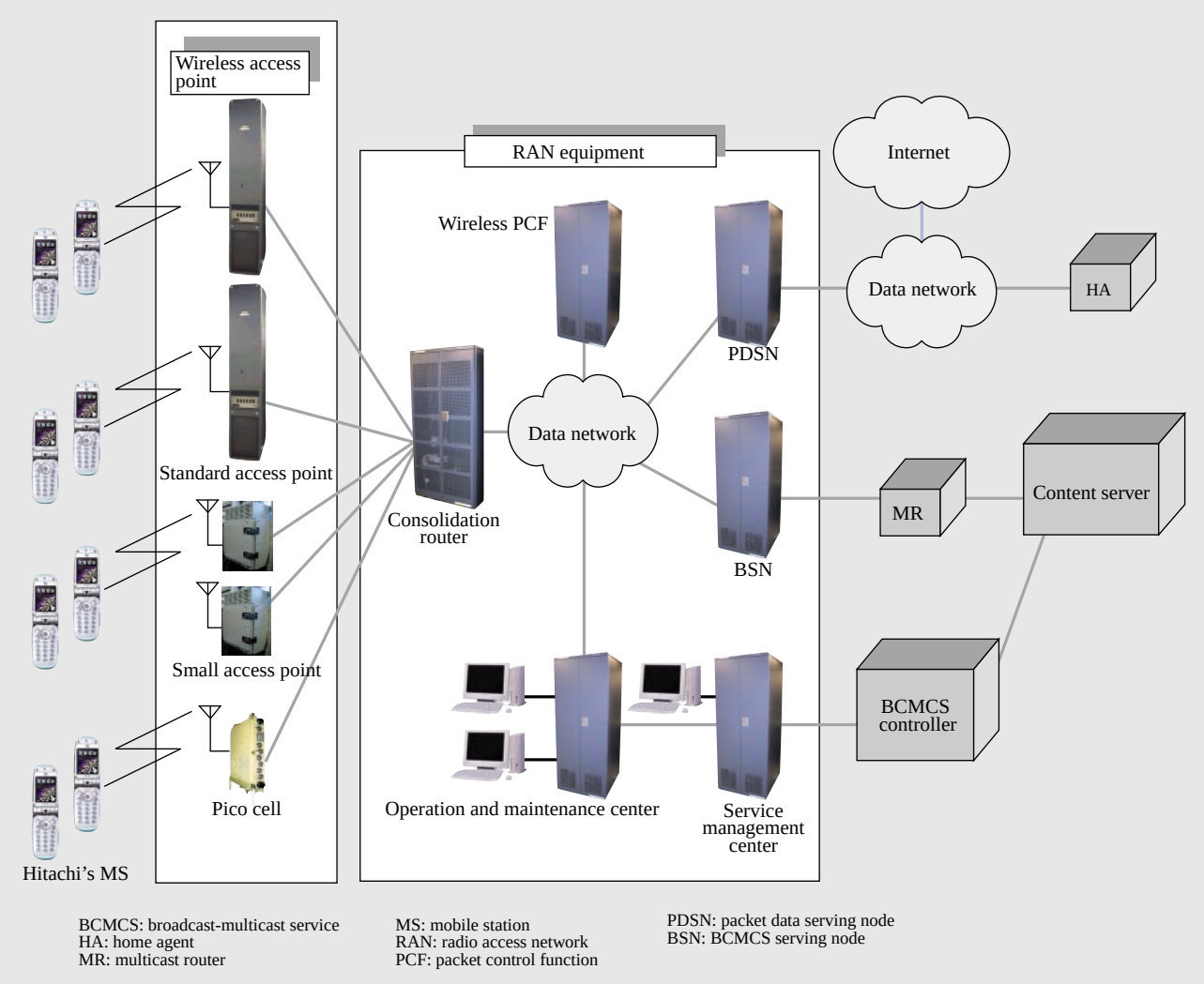

Fig. 1—Example Configuration of 1xEV-DO System.
With a maximum downlink transmission rate (from a wireless access point to a mobile terminal) of 2.4 Mbit/s and a maximum uplink (the opposite direction) rate of 144 kbit/s, 1xEV-DO (1x evolution-data only) system provides an ADSL (asymmetric digital subscriber line) for extremely high-speed mobile communications.

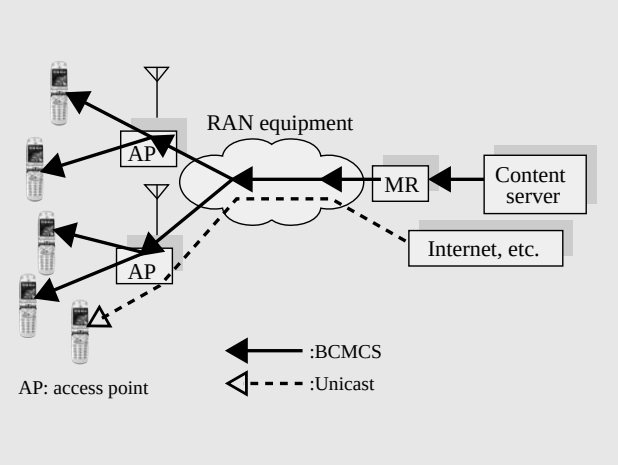

Fig. 2—Example of BCMCS Provided by 1xEV-DO System.
An example of reproducing data by network devices and wireless access points, and multicasting to mobile stations is shown.

will be available as BCMCS based on the 1xEV-DO standard.

(1) Simultaneous distribution of electronic books to multiple users
(2) Broadcasting of TV programs by streaming
(3) 1-to-*N* transmission (transceiver-type services)
(4) *N*-to-*N* transmission (teleconferencing by mobile phone)

Moreover, it is possible to broadcast to either a certain wireless access point or a group of access points only. This means that, for example, sports commentary can be delivered to those mobile terminals operating in that area, thereby offering services providing additional value to users carrying mobile terminals for BCMCS. It is expected that new services like those stated above will become available by means of sharing the same information on multiple mobile stations.

Services Utilizing QoS Function

The 1xEV-DO standard for packet communication systems optimized for "best effort" services is inadequate for providing streaming applications (which are sensitive to jitter) and VoIP (voice over Internet Protocol) applications (which are sensitive to time delay). By packaging a QoS function in our 1xEV-DO system, however, it has become possible to offer streaming services, providing IP (Internet Protocol) videophone and video.

TECHNOLOGIES FOR ENABLING QoS CONTROL AND BCMCS

Technology for Enabling BCMCS

In regards to realizing BCMCS with transmission speeds of 200-400 kbit/s under the 1xEV-DO standard, data-error correction is necessary. In the case of the unicast transmission method, even if an error occurs during data transmission to a mobile station, the data is re-transmitted to that mobile station individually, thereby correcting the error.

In the case of BCMCS, however, data is transmitted to multiple stations simultaneously, so it is not possible to re-transmit the data to each mobile station individually. In that case, even if a transmission error occurs, it can be vigorously corrected by using the R-S (Reed-Solomon) coding method. By adding *R* parity rows to *K* data rows, the R-S coding method can correct up to *R* rows containing data errors. And even if burst-type errors occur, this method can correct them (see Fig. 3).

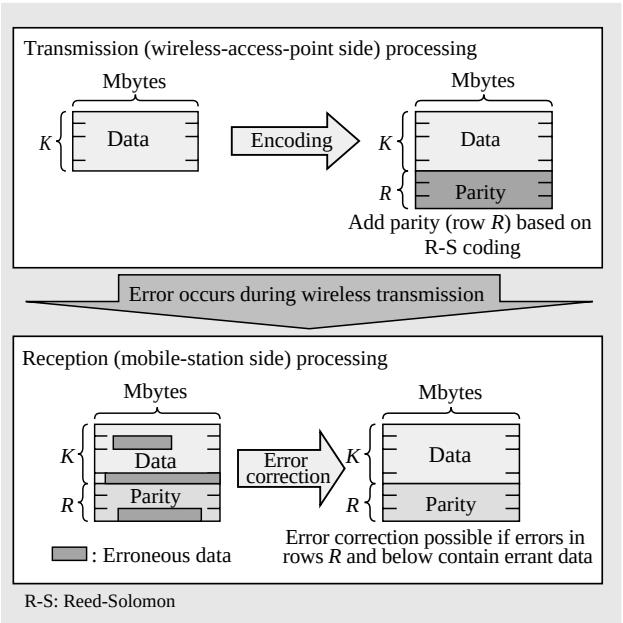

Fig. 3—R-S Coding Method.
By adding R parity rows to K data rows, the R-S coding method can correct up to R rows containing data errors.

As for the R-S coding method, if the ratio of *R* (parity) to *K* (data) is increased, the proportion of correctable errors can be increased. For example, in the case that a single radio access point covers a large area, even if the radiowave status in that area is poor, it is possible to decrease the data error rate by using R-S coding. In response to the radio spectrum and radiowave status required for the previously mentioned applications and services, the developed 1xEV-DO system offers the choice of the optimum pair from seven combinations of *K* and *R* stipulated under the 3GPP2 standard, thereby allowing a flexible area layout. In addition, comparing the case that error correction by R-S coding is performed with the case that it is not performed reveals that gain reduction is improved by 1 to 3.5 dB by application of R-S coding.

Technology for Enabling QoS Control

1xEV-DO was originally developed to provide "best effort" (i.e. communication under a non-guaranteed state) services, and QoS has been attained by adding improvements to 1xEV-DO systems. As a result, even when used for real-time communication applications, the system accomplishes good transmission characteristics, namely, low delay and low jitter. QoS control is accomplished by three main functions:

(1) QoS scheduling of downlink data transmitted to mobile stations from access points,
(2) rate-transition-probability tuning using parameters when uplink data is transmitted from mobile stations to access points, and
(3) admission control by call priority.

When an access point transmits data to mobile stations, the QoS scheduling of downlink data reduces delay and jitter by transmitting data preferentially to mobile stations targeted for priority control.

Conventional transmission of downlink data by a 1xEV-DO system adopts a method for reducing the sense of unfairness resulting from preferential allocation; that is, time slots are allocated preferentially to mobile stations that can expect high throughput due to good radiowave status, but arbitrary time slots are allocated to mobile stations that can only transmit at low throughput due to poor radiowave status. By bolstering this capability of this scheduler (and its algorithm for time slot allocation), low delay and jitter required for real-time applications are attained. That is to say, in the case that a mobile station under poor

radiowave conditions is targeted for QoS control while a mobile station under good radiowave conditions is executing "best effort" transmission, priority is given to data transmission to the mobile station targeted for QoS control.

As regards uplink data transmission, multiple mobile stations exist, and if data transmission at high rate is attempted for each, the radiowave output power transmitted from each mobile station will become high; consequently, demodulation of the received signals at the radio access points becomes impossible owing to mutual interference between the signals. To avert such circumstances, the wireless access points monitor the amount of interference, and if that amount approaches the value that causes trouble for demodulation, they lower the radiowave output power in response to all mobile stations. As a result of this control method, each mobile station can lower its radiowave transmission output power by lowering its transmission rate at a designated probability sent beforehand from an access point.

On the other hand, when interference is low, the access point allows radiowave transmission output power to be increased in accordance with the status of each mobile station. Each mobile station can increase its radiowave output power and transmission rate at a designated probability sent beforehand from the access point. For executing QoS control of uplink data, by increasing the probability of raising transmission rate of only those mobile stations targeted for QoS control, and by decreasing the probability of lowering transmission rate, it is possible to decrease the delay in transmission to those mobile stations (see Fig. 4).

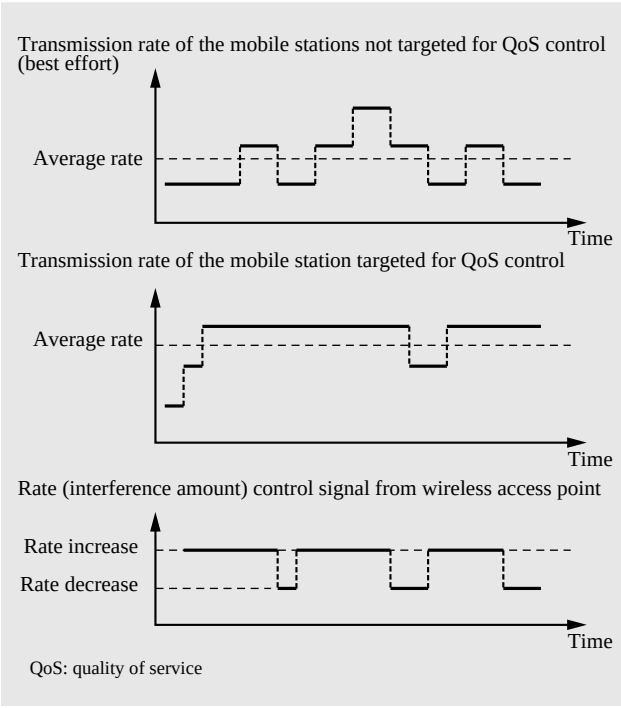

Fig. 4—QoS Control by Transition Probability of Uplink Rate. The transmission rate of the mobile station targeted for QoS control is set to be easy to increase but difficult to decrease; therefore, compared to the average transmission rate of other mobile stations, it is higher and its stability is assured.

In addition to the above-mentioned priority control of data transfer, admission control (i.e. priority-controlled calls) is provided. In the case that the radio-reception environment of a mobile station targeted for priority control is poor, to execute data transmission at a low rate, the time slot appropriate for that station is lengthened. In consequence, the throughput of the data transmitted from the wireless access point is lowered. As a result of that, when the number of connected mobile stations targeted for priority control increases, the bandwidth assigned to mobile stations not treated with priority control decreases appreciably. To avert this situation, the number of connected mobile stations targeted for priority control is limited so that the bandwidth assigned to mobile stations without priority control is assured.

By implementing a priority-control configuration for a 1xEV-DO system centered on the technical factors described above, delay and jitter have been reduced so that real-time applications such as VoIP services are possible.

FUTURE EXPECTATIONS REGARDING QoS AND BCMCS

Expanding BCMCS Functions

With regard to 3GPP2 specifications, a version of the 1xEV-DO BCMCS standard with enhanced features (known as "enhanced BCMCS") was completed in January of 2006. By utilizing an improved modulation scheme OFDM (orthogonal frequency division multiplexing), enhanced BCMCS decreases interference between transmitted signals between wireless access points, and a method for improving reception quality with enhanced BCMCS is being investigated. Through these improvements, increasing the present throughput range of BCMCS by about three times, namely, from 200-400 kbit/s up to 600-1,200 kbit/s, was achieved.

Expanding QoS Functions

Regarding 3GPP2 specifications, the specification of the next-generation version of the 1xEV-DO Revision0 systems currently in service, namely, 1xEV-

DO RevisionA, was completed in March 2004. As the main features of RevisionA, speeding up of the uplink and improved QoS response are being cited. Three key points concerning the QoS response are listed as follows:

(1) Separate control of each logical link

Each radio link is logically split up into multiple flows, and individual QoS control is performed with respect to each flow. As a result of this QoS control scheme, for example, in the case of conducting voice telephony and Web browsing at the same time, low-delay QoS is allocated to the former, and high-throughput is allocated to the latter. In other words, it is possible to control QoS individually.

(2) Improved utilization efficiency of downlink

To handle services transmitting voice-telephony-like small packets in a short cycle, two functions have been added to the downlink: a "multi-user-packet function," which stores packets of multiple users in blocks in one wireless packet, and a "short-packet function," which makes a wireless packet itself smaller and thereby shortens the transmission time for each packet.

(3) Improved uplink-rate control method

The uplink-rate control method has been improved from the conventional one based on probability to one based on data rate. As regards this data-rate-based control method, a mobile station determines a target average transmission rate in response to factors such as the interference amount of radiowaves, and the transmission rate is chosen in order to keep the difference between the actual rate and the target to a minimum at all times. This method thus substantially reduces jitter and delay.

As a participant in 3GPP2, Hitachi will continue to contribute to further expansion of the functions described above.

CONCLUSIONS

With its wireless data-transmission capability, mobile telephony—developed on the basis of voice communications—has begun its integration with the Internet. From now onwards, it is considered that, as wireless versions of ADSL (asymmetric digital subscriber line) services, mobile telephony will become even more widespread. By adding BCMCS and QoS functions to a 3rd-generation 1xEV-DO mobile communication system, we have improved utilization efficiency of wireless access networks as well as added new value to mobile telephony systems in the form of broadcasting and IP-videophone services. In accordance, given these improvements to mobile telephony, we expect these application domains to continue to expand rapidly.

REFERENCES

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