Technology Reports

RRE Shared between W-CDMA and LTE Systems

NTT DOCOMO plans to initiate LTE services at the end of 2010, and for part of some base station equipments, NTT DOCOMO has developed RRE capable of supporting both W-CDMA and LTE systems, and began commercial deployment of these units in October, 2009. With this equipment, it will be possible to expand the LTE system efficiently, adding it to the W-CDMA system, by simply installing additional components for baseband processing and maintenance functions for the LTE system base station equipment when initiating LTE system services.

Radio Access Network Development Department

Yoshitsugu Shimazu
Shingo Suwa
Masayuki Motegi†
Takayuki Watanabe

1. Introduction

NTT DOCOMO is planning to start LTE system services at the end of 2010. This system uses 3G frequency bands, provides high-speed data downlink at 100 Mbit/s or greater and uplink at 50 Mbit/s or greater, and provides improvements in latency and efficiency of frequency use. NTT DOCOMO will commence LTE services using the same 2 GHz band as is being used for the W-CDMA system, so the LTE system can be introduced using antenna and other equipment already in place, and some of base station equipment (evolved NodeB (eNB)) can be made to support both W-CDMA and LTE systems, providing further benefits economically and in the installation process.

Accordingly, we have developed 2-GHz-band, Remote Radio Equipment (RRE) (**Photo 1**) for use in LTE system base station equipment, which is capable of supporting both W-CDMA and LTE systems and is equivalent to the outdoor Optical Feeder Transmitter and Receiver (OF-TRX) of a high-density multi-band BTS[1] for the

(a) Manufacturer A (b) Manufacturer B (c) Manufacturer C

Photo 1 External view of RRE

† Currently R&D Strategy Department

W-CDMA system.

With this equipment, it will be possible to expand the LTE system efficiently when services start, adding it to the W-CDMA system by simply installing Base station Digital processing Equipment (BDE) for baseband processing and maintenance functions in the LTE system base station equipment. Also, the LTE RRE is smaller, lighter and consumes less power than previous equipment supporting only W-CDMA, providing a way to improve on the installation process and reduce operating costs.

In this article, we describe technology sharing RRE between W-CDMA and LTE systems. We also discuss future expansion toward introducing LTE system using this RRE.

2. Technology for Sharing between W-CDMA and LTE Systems

2.1 Radio Technology

The configuration of the RRE transmitter/receiver component is shown in **Figure 1**. In the radio part of the RRE, the W-CDMA and LTE systems use different frequencies within the same frequency band, so the following technologies for sharing are adopted to allow for a shared base station combining both systems.

1) Transmitter

The transmitter extracts the baseband signal[*1] from each of the carriers for the W-CDMA and LTE systems from the Common Public Radio Interface (CPRI)[*2] signal. All of the carriers for the W-CDMA and LTE systems are then re-multiplexed after passing the W-CDMA system data through a Root-Raised Cosine (RRC) filter[*3] and the LTE system data through a rectangular filter[*4]. Then, the signals are Digital-to-Analog (D/A) converted, quadrature modulated[*5], frequency converted to the carrier frequency, amplified through the transmitter power amplifier, and transmitted as a radio signal to the mobile terminal. In the transmitter power amplifier, we have increased efficiency through distortion compensation using digital pre-distortion technology[*6]. 16 Quadrature Amplitude Modulation (16QAM)[*7] for HSDPA in the W-CDMA system, as well as 64QAM[*8] used by the LTE system, are both sup-

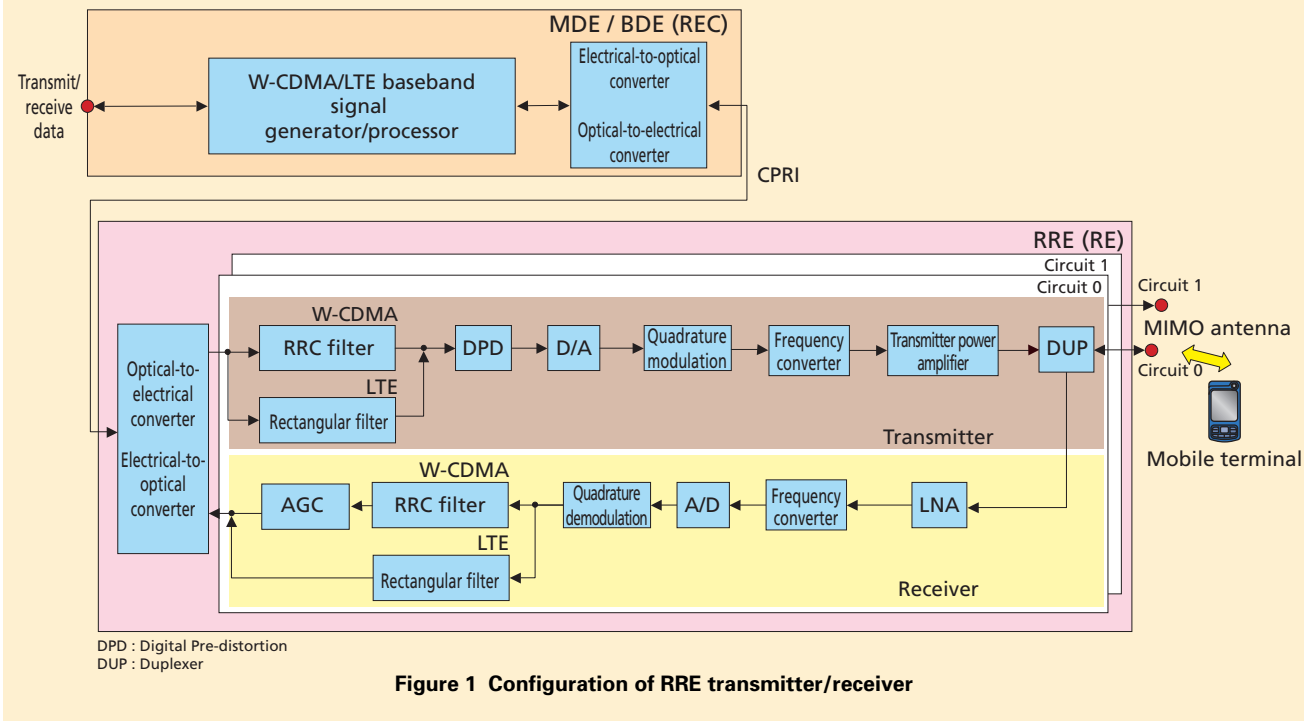

Figure 1 Configuration of RRE transmitter/receiver

*1 **Baseband signal**: The digital signal before conversion to radio frequencies.
*2 **CPRI**: Internal interface specification for radio base stations. CPRI is also the industry association regulating the specification.
*3 **RRC filter**: A digital filter used to shape a waveform.
*4 **Rectangular filter**: A digital filter that only allows frequency components in a particular range on the frequency axis to pass.
*5 **Quadrature modulation**: A modulation method in which two sinusoidal signals with phase difference of 90° are added after multiplication.

ported, meeting a modulation accuracy of 8%, the quality requirement for LTE.

2) Receiver

The received signal is amplified by a Low-Noise Amplifier (LNA)[*9], and then frequency converted, A/D converted, and quadrature demodulation is applied. Then, Automatic Gain Control (AGC)[*10] is applied to the W-CDMA system data, controlling to maintain a constant output level independent of the received signal input level, leading to a reduction in the number of bits required in the latter digital processing parts, and a reduction in the load on the baseband processing. On the other hand, the amount of data transmitted at the same time by the LTE system is greater and the instantaneous variation of the total received power level is larger than with the W-CDMA system, so we used a method without AGC on the LTE system data to improve the reception quality. Thus, we were able to implement receiver technologies optimized for both W-CDMA and LTE systems by adopting receiver technology optimized to each system, resulting in no performance degradation in either.

2.2 CPRI Technology

Like the high-density multi-band BTS outdoor OF-TRX for W-CDMA, the RRE supports CPRI [1] and can be connected with equipment from multiple venders and to the Modulation and Demodulation Equipment (MDE) in W-CDMA base station equipments. Note that with CPRI, the Radio Equipment Control (REC)[*11] is defined as the MDE for W-CDMA and the BDE for LTE, and the Radio Equipment (RE)[*12] is defined as the OF-TRX for W-CDMA and the RRE for LTE.

The following technology for sharing was adopted in the RRE for both the W-CDMA and LTE systems.

1) Optical Interface Bit Rate

The radio link for W-CDMA implements up to four carriers, each of bandwidth 5 MHz with up to 14.4 Mbit/s on the downlink and up to 3.6 Mbit/s on the uplink. In contrast, the LTE system implements up to 100 Mbit/s on the downlink and 50 Mbit/s on the uplink using a bandwidth of 20 MHz. Compared to W-CDMA, LTE allows higher data rates, so the baseband signal has twice as much data and the optical interface between REC and RE requires double the bit rate. In order to allow both systems to operate in the RRE, individually and shared, two optical interface bit rates are supported: 1228.8 Mbit/s (W-CDMA), and 2457.6 Mbit/s (LTE). An auto-negotiation function switches between the two optical interface bit rates, depending on which system it is connected to.

2) C&M Signal

The High-level Data Link Control (HDLC)[*13] protocol is used for Control & Management (C&M) signal[*14] between REC and RE. With the shared configuration, the W-CDMA and LTE systems each independently monitors the RRE state and the use of each carrier, and send and receive C&M signals. Note that the HDLC bit rates used independently by the W-CDMA and LTE systems are each 960 kbit/s, totaling 1,920 kbit/s for the shared W-CDMA and LTE system configuration. The C&M signals for each of the W-CDMA and LTE systems are identified and differentiated using a single system identifier bit. This allows the RECs for each system not to change their C&M signal processing depending on whether the RE is shared or not.

3) Connection Configuration Identification

Since the optical interface and HDLC bit rates are decided by the REC configuration, the RE is able to determine the REC configuration from the combination of optical interface and HDLC bit rates.

4) Baseband Signal (IQ Data) Mapping

The baseband signal is transmitted as IQ data in the CPRI, which is the interface between REC and RE. Examples of the IQ data mapping for W-CDMA-only operation (3G link), LTE-only operation (LTE link) and shared operation (shared link) are shown in **Figure 2**. The 3G link maps IQ data for each carrier and the LTE link uses different mappings depending on the operational bandwidth. The amount of data that can be sent from the REC to the RE is limited, but by changing the antenna and carrier allocation on the

*6 **Digital pre-distortion technology**: A technology which improves the distortion characteristics of an amplifier by applying the inverse of the distortion characteristic of the amplifer to the signal beforehand.

*7 **16QAM**: A digital modulation method that allows transmission of 4 bits of information simultaneously by assigning one value to each of 16 different combinations of amplitude and phase.

*8 **64QAM**: A digital modulation method that allows transmission of 6 bits of information simultaneously by assigning one value to each of 64 different combinations of amplitude and phase.

*9 **LNA**: An amplifier able to reduce the effects of noise generated by the device connected to its later stages because it generates very little noise itself.

shared link according to the number of carriers and bandwidth used by W-CDMA and LTE systems, a system shared between W-CDMA and LTE can be implemented without restriction due to data amount.

3. System Expansion Using the RRE

A diagram of system expansion using the RRE is shown in **Figure 3**. When the RRE is first installed for commercial use, it is connected directly to the MDE of the W-CDMA base station by optical cable, for operation as W-CDMA radio equipment.

When LTE is introduced, the RRE is connected by optical cable to the BDE of the LTE base station equipment. Then, the W-CDMA system is connected through the BDE of the LTE system, which has a relay function for the W-CDMA CPRI signal.

Note that in the future, if the system operation goes to LTE exclusively, the MDE and cable connecting it to the BDE can simply be removed.

4. Equipment Overview

The basic specifications for the RRE are shown in **Table 1**. The initially developed RRE operates in the 2 GHz band. The transmit and receive systems each have two circuits, supporting 2×2 Multiple Input Multiple Output (MIMO)[*15]. Also, CPRI transmission supports rates of 1228.8 Mbit/s and 2457.6 Mbit/s, allowing implementation of W-CDMA-only operation connected directly to the MDE, LTE-only operation connected directly to the BDE, and shared W-CDMA/LTE operation with the MDE connected through the BDE.

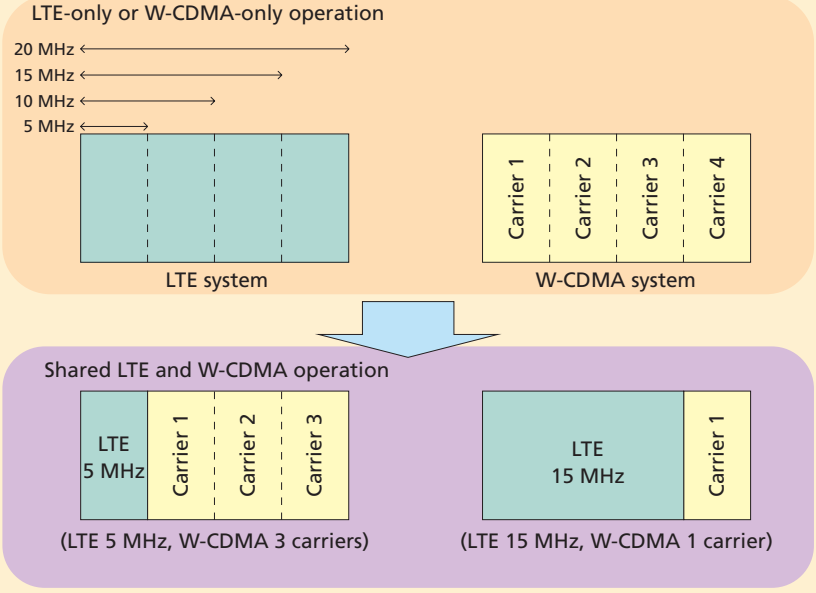

Figure 2 IQ Data mapping example

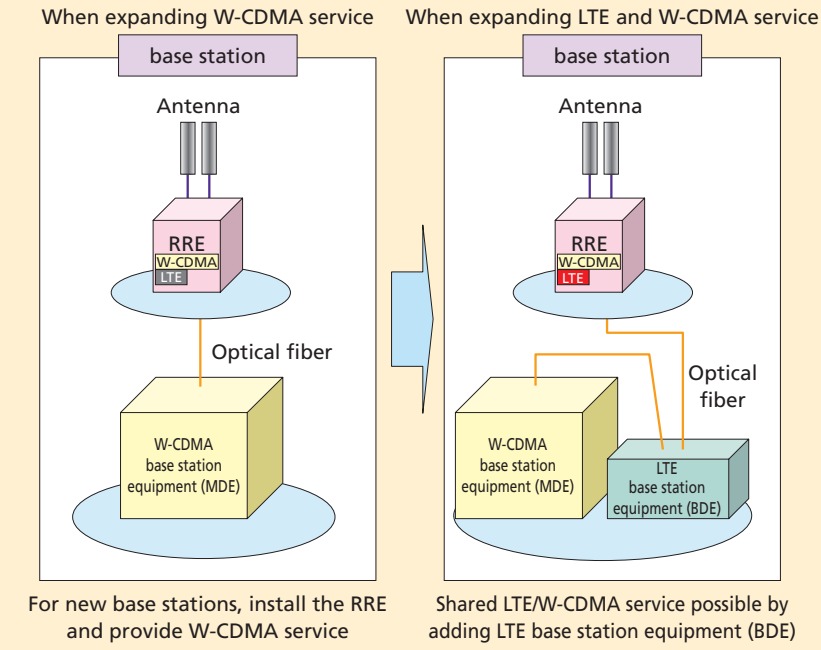

Figure 3 Installing the RRE in base station

*10 **AGC**: Control which maintains the output at a fixed level independent of the level of the received input signal.
*11 **REC**: The radio control component of a base station. Handles control of digital baseband signal processing and base station monitoring.
*12 **RE**: The radio component of a base station. Handles amplification, modulation/demodulation and filtering of the radio signal.
*13 **HDLC**: A data transmission control procedure that provides control in units of bits. It is fast and highly efficient, and makes highly reliable data transmission possible.
*14 **C&M signal**: Monitoring and control signal between the REC and RE.

Furthermore, the connectors for the various external interfaces were designed to be compatible with earlier OF-TRX equipment, so that during installation, replacing such equipment can be done by simply changing existing cable connections, and without additional work to install new cables. This contributes to controlling Captial Expenditure (CAPEX) when deploying LTE, which is one of the requirements set by the 3GPP [2] for LTE.

Optimizing the specifications in these ways enabled an RRE implementation which is smaller, lighter and consumes less power than earlier OF-TRX equipment.

Table 1 RRE basic specifications

	W-CDMA/LTE system shared RRE	W-CDMA system OF-TRX equipment (for reference)
Transmit/receive frequency band	2 GHz band	
Number of carriers	Max. 4 carriers (W-CDMA) Max. 1 carrier (LTE)	Max. 4 carriers
Number of sectors	1 sector	
Maximum transmit power	10 W/carrier (W-CDMA) 10 W/5 MHz, 20 W/10 MHz, 30 W/15 MHz, 40 W/20 MHz (LTE)	10 W/carrier
Size	20.5 ℓ or less	30 ℓ or less
Weight	20 kg or less	30 kg or less
Power consumption	310 W or less	
CPRI transmission speed	When connected to MDE : 1228.8 Mbit/s When connected to BDE : 2457.6 Mbit/s	1228.8 Mbit/s

5. Conclusion

In this article, we have described technology for sharing between W-CDMA and LTE that has been adopted in the advanced development of shared RRE for W-CDMA and LTE systems. This technology is used as part of the radio equipment for LTE base stations. We also explained how this LTE RRE would be used for system expansion when LTE is introduced.

We will continue to develop LTE base station equipment contributing to the introduction of LTE services.

REFERENCES

[1] H. Ohyane et. al: "Base Station Supporting IP Transport," NTT DoCoMo Technical Journal, Vol.9, No.1, pp.7-12, Jun. 2007.
[2] 3GPP TS25.913 V7.3.0: "Requirements for Evolved UTRA (E-UTRA) and Evolved UTRAN (E-UTRAN)," 2006.

*15 **MIMO**: A wireless communication technique that utilizes multiple paths between multiple antennas at the transmitting and receiving ends to exploit spatial propagation properties, causing the capacity of wireless links to increase in proportion with the number of antennas.