LTE | Base Station Equipment | W-CDMA/LTE Shared System

Technology Reports

Special Articles on "Xi" (Crossy) LTE Service—Toward Smart Innovation—

LTE Base Station Equipments Usable with W-CDMA System

*We have developed LTE system base station equipment which enables efficient and economical deployment of the LTE system, for realization of the "Xi" (Crossy)*1 *LTE service that began operation in the Tokyo, Nagoya and Osaka regions in December 2010. This equipment was designed to save energy and reduce cost by using new technology to significantly reduce power consumption, and to improve installation and economy through sharing between the LTE systems and existing W-CDMA systems.*

Radio Access Network Development Department

Yoshitsugu Shimazu
Hidehiko Ohyane
Takayuki Watanabe
Tatsuro Yajima
Shingo Suwa

1. Introduction

NTT DOCOMO began operation of the LTE system in Tokyo, Nagoya and Osaka regions in December 2010. This system uses 3G frequency bands, providing 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.

Base station equipment for the LTE system (evolved Node B (eNodeB)) is equipped with the radio access and control technology, which is under provision by Base Transceiver Stations (BTS) and IP-Radio Network Controllers (IP-RNC) in the W-CDMA system. In addition, eNodeB connects with the Evolved Packet Core (EPC) through all-IP networks.

NTT DOCOMO launched the LTE system 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 parts of the eNodeB can support both W-CDMA and LTE systems, providing further benefits economically and in the installation process. Accordingly, for the eNodeB radio equipment, we developed 2 GHz band Remote Radio Equipment (RRE)[1], which was introduced commercially in October 2009, as well as Base station Radio processing Equipment (BRE) and Low-power Radio Equipment (LRE) to be added later. Furthermore, the digital processing component of the eNodeB was also equipped with technology to be shared by both W-CDMA and LTE systems.

In this article, we describe the features of eNodeB and the technology shared by both W-CDMA and LTE systems.

2. LTE Base Station Equipment

2.1 Application Areas

Several types of eNodeB equipment were developed to support various installation and connectivity structures

*1 **"Xi" (Crossy)**: "Xi" (read "Crossy") and its logo are trademarks of NTT DOCOMO.

(**Figure 1**). We were able to reduce the scale of development by using an architecture which uses the base band signal processing unit, called the Base station Digital processing Equipment (BDE), as a common component, and enabling support of various application scenarios by connecting radio equipment to the BDE. Radio equipment can be connected to the BDE for use in various situations as described below.

- RRE

  Outdoor equipment installed near the antenna. Spot-like areas can be supported with extensions to various locations using RRE units.

- BRE

  Indoor equipment that is installed in a building when there is no space near the antenna.

- LRE

  Indoor equipment that is for covering indoor areas. By connecting LREs to a Radio-over-Fiber (RoF) system [2], the inside of an entire building can be covered with multiple branches.

2.2 Migration from the W-CDMA System to the LTE System

Installing entirely new base station equipment for the LTE system presented various difficulties in terms of cost, installation space, and technical issues such as synthesizing signals with the W-CDMA system. Accordingly, the eNodeB was developed to utilize as much of the W-CDMA system equipment as possible (**Figure 2**).

1) Development of Radio Equipment Supporting both W-CDMA and LTE (RRE/BRE/LRE)

In order to use the equipment such as antennas built for the W-CDMA system as-is, we developed radio equipment (RRE/BRE/LRE) supporting both W-CDMA and LTE systems. Also, RRE was shipped first, allowing prepa-

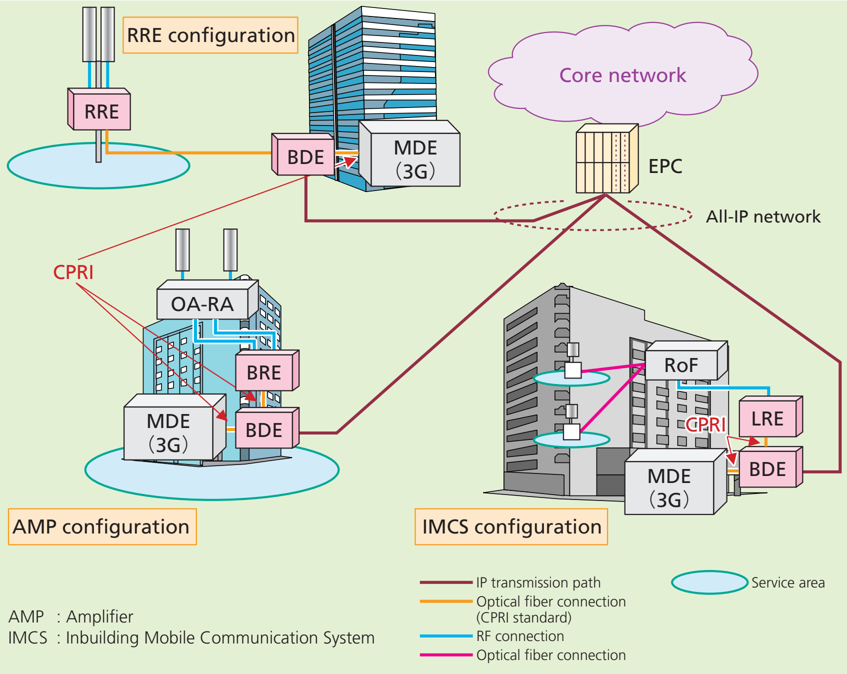


Figure 1 Types of base station equipment for LTE services

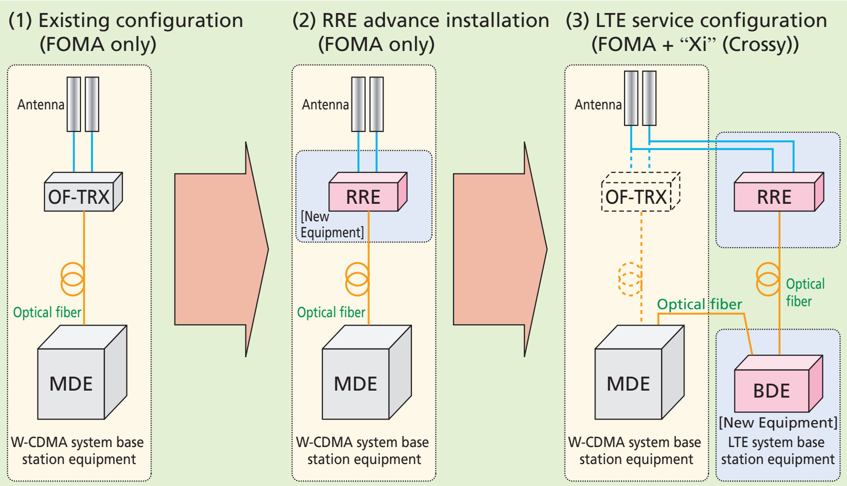


Figure 2 Example migration from the W-CDMA system to the LTE system

ration to proceed before the "Xi" (Crossy) service launched and helping to reduce equipment costs.

2) Combined Optical Interface Technology

In order to continue using the existing digital processing component of the BTS, called the Modulation and Demodulation Equipment (MDE), the BDE adopted technology integrating an optical interface connected with the MDE. This reduced the number of optical fibers required for connecting to RREs and other equipment, also contributing to reducing equipment costs.

3) Sharing Office Rack Space

In consideration of indoor equipment space, the hardware was built so that BDE, BRE and LRE could be added to racks housing of W-CDMA system radio-equipment.

2.3 Energy-savings and Cost Reductions in Base Stations

The eNodeB has achieved major reductions in power consumption and economical installation through the use of new technology. The RRE equipment has reduced power consumption by approximately 30% relative to the Optical Feeder-Transmitter and Receiver (OF-TRX), which is the optical extension unit for the W-CDMA system. Also, the cost-per-bit of the base station is about one-third compared to the W-CDMA system.

3. Equipment Overview

3.1 BDE Specifications

The BDE is a shelf-unit capable of providing LTE service for up to six sectors and with channel bandwidth of up to 20 MHz per sector (**Table 1**, **Photo 1**). A single BDE unit can accommodate up to six Common Public Radio Interface (CPRI)[*2] links, and Radio Equipment (RE)[*3] for each of these CPRI links can be selected for flexible area deployment.

The BDE is composed of a transmission path interface called the High-WaY-INterFace (HWY-INF), a base station controller component called the eNodeB-CoNTroller (eNB-CNT), a Base Band signal processor (BB), a Transmitter and Receiver INterFace (TRX-INF) and a CPRI MUltipleXer /demultiplexer (CPRI-MUX).

The HWY-INF has signal processing functions for the transmission path

Table 1 BDE basic specifications

Number of carriers	1
Number of sectors	Up to 6
Channel bandwidth	5 MHz, 10 MHz, 15 MHz, 20 MHz
Throughput	Downlink: 150 Mbit/s Uplink: 50 Mbit/s
Transmission system	2×2 MIMO, transmit diversity
User capacity	210 Users/5 MHz/sector
Size	H1,135×W600×D600 mm*
Weight	120 kg or less*
Power consumption	1.2 kW or less
Number of CPRI link connections	Up to 6
Transmission path class	1000BASE-SX: Up to 2 lines

* Values as installed in rack

Photo 1 BDE external view

*2 **CPRI**: Internal interface specification for radio base stations. CPRI is also the industry association regulating the specification.

*3 **RE**: The radio component of a base station. Handles amplification, modulation/demodulation and filtering of the radio signal.

interface below the IP layer. This functional component can accommodate up to two physical 1000BASE-SX[*4] lines. The eNB-CNT has call-control functions, configuring and releasing circuits and managing the connections with mobile terminals, as well as trunk control functions, configuring and releasing transmission path with the core network, and it also implements monitoring and control of the eNodeB, exchanging maintenance and monitoring signals with operations systems. The BB performs error-correction coding, radio-frame building, data modulation, time and frequency conversions, and Multiple-Input Multiple-Output (MIMO)[*5] transmission on the transmission signal, and time/frequency conversion, data demodulation, signal separation and error correction decoding on the received signal. It also has functions for Hybrid Automatic Repeat reQuest (HARQ)[*6], Adaptive Modulation and Coding (AMC)[*7] control, scheduling and others. The TRX-INF has functions to convert the baseband signals and maintenance/monitoring signals to CPRI format. The CPRI-MUX has functions to separate and multiplex CPRI signals from the BTS and eNodeB.

3.2 RRE/BRE/LRE Specifications

Each of the RRE, BRE and LRE support radio frequencies in the 2 GHz band. The BRE is a shelf unit supporting up to six sectors, and the RRE and LRE are both self-contained units supporting a single sector (**Table 2**, **Photo 2**). The main functional components of the BRE are the TRX-INF, as described above, the Transmitter/Receiver (TRX), and the Transmission-Power Amplifier (T-PA).

The TRX has functions to convert the input baseband signal to a transmission Radio Frequency (RF) signal[*8] using quadrature modulation, and to convert the received RF signal to a baseband signal after A/D conversion. The T-PA amplifies the power of the transmission RF signal from the TRX to regulation levels. Note that the received RF signal is amplified using an Open-Air Receiver Amplifier (OA-

Table 2 BRE/RRE/LRE basic specifications

Item	BRE*	RRE	LRE
Transmit/receive frequency band	2 GHz band		
Number of carriers	3G: up to 4 LTE: max. 1		
Number of sectors	Up to 6	1	
Max. transmit power	10 W/5 MHz/branch	5 W/5 MHz/branch	0.125 mW/5 MHz/branch
Size	H : under 1,135 mm W : under 600 mm D : under 600 mm	Under 20.5 ℓ	Under 15 ℓ
Weight	230 kg or less	20 kg or less	10 kg or less
Power consumption	4.5 kW or less	310 W or less	100 W or less

* Values as BDE, BRE both installed together in a rack

(a) BRE (lower shelf)

(b) LRE

(c) RRE

Photo 2 RRE/BRE/LRE external views

*4 **1000BASE-SX**: A Gigabit ethernet standard supporting speeds up to 1 Gbit/s.

*5 **MIMO**: A signal transmission technology that uses multiple antennas for transmission and reception to improve communications quality and spectral efficiency.

*6 **HARQ**: A transmission technology that resends data for which errors have occurred after error correction and decoding on the receiver side.

*7 **AMC**: A method for adaptively controlling transmission speed by selecting an optimal data modulation scheme and channel coding rate according to reception quality as indicated, for example, by the signal-to-interference power ratio.

*8 **RF signal**: A Radio-frequency band signal.

RA) installed directly beneath the transmit/receive antenna, and this can also be used as the BTS OA-RA, which makes installation of the BRE easier and helps decrease running costs.

Besides these, we are also developing BRE equipment with a 3G RF interface (3GRF-INF) component. A BRE with a 3GRF-INF can share the antenna and other external equipment, by inputting the RF signal from the BRE, which is not supported by CPRI, before amplification.

The LRE has a TRX-INF and TRX, and implements connections with transmission equipment such as RoF systems.

4. LTE Base Station Specialized Technology

4.1 Technology Shared between Systems

When introducing LTE systems, it is desirable to use the resources of the existing W-CDMA systems as they are. For RE, the radio characteristics of W-CDMA and LTE are different, so existing equipment cannot be used as it is. However, by having a CPRI-MUX to the Radio Equipment Control (REC), the W-CDMA system can be supported without changing the existing MDE. With the CPRI-MUX, the W-CDMA system can operate without the MDE needing to distinguish between independent 3G and 3G/LTE shared configurations.

The CPRI-MUX has the following functions.

1) Phase Correction Function

Both the W-CDMA and LTE systems require the clock source for the baseband signal and RE to be the same. The basic clock source must be the same as the REC in each system, but the RE cannot operate according to more than one clock, so it must use one or the other. The CPRI-MUX uses the LTE system clock source as the basic standard for the RE clock source. The signal from the W-CDMA system has a different clock source, so the CPRI-MUX must calculate the difference between the clock sources of each system and correct the phase of the W-CDMA signal to match that of the LTE system. In this way, the W-CDMA system can also transmit and receive without a mismatch in clock timing.

If the CPRI-MUX cannot acquire the clock source of the LTE system, it switches to the W-CDMA system clock source. This allows the W-CDMA system to continue to operate without effect if the LTE system REC cannot operate.

2) IQ[*9] Data Mapping

Since the amount of data that can be sent and received between REC and RE is limited, the baseband signal (IQ Data) is allocated according to the number of carriers and bandwidth of the W-CDMA and LTE systems. The CPRI-MUX implements remapping of IQ data from the W-CDMA and LTE systems.

3) Link control

With configurations shared by both systems, the CPRI-MUX terminates the MDE/BDE/RE CPRI, so for example, the MDE cannot know the link state between the BDE and RE. In order to avoid inconsistency in the link state between REC and RE, the CPRI-MUX controls the BDE/RE and BDE/MDE links in a coordinated fashion.

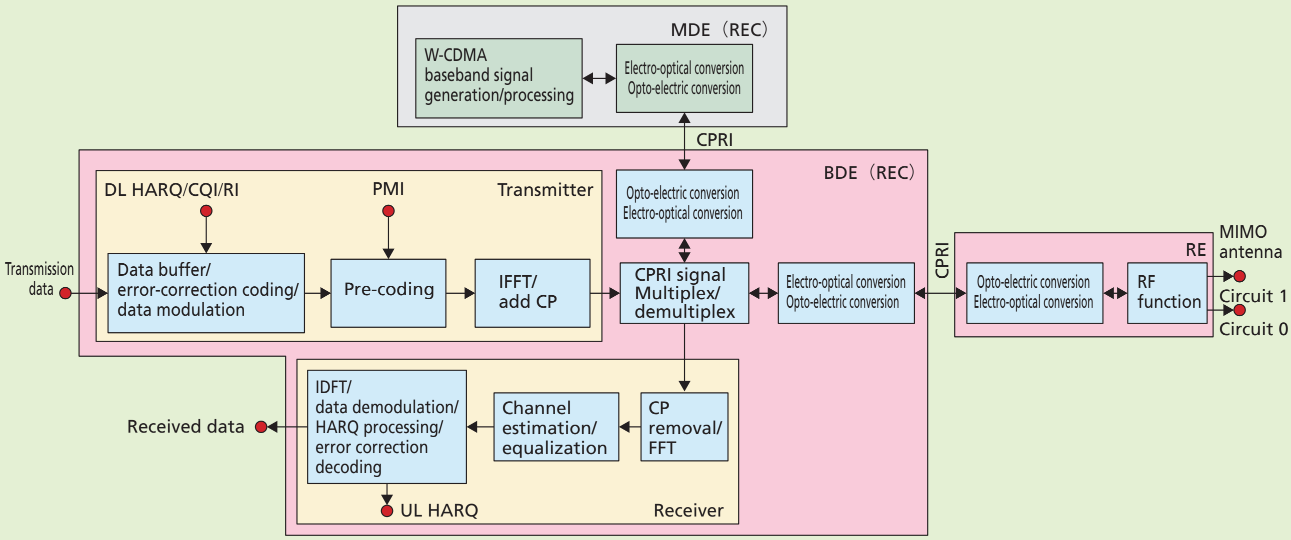
4) Frame Timing Adjustment

The MDE derives the delay in the optical cable between REC and RE from the transmission and reception timing of the CPRI signal, but for shared system configurations, the CPRI-MUX terminates each link, so this does not allow it to determine the optical-cable delay between MDE and CPRI-MUX. However, by considering the optical-cable delay between CPRI-MUX and RE and adjusting the frame timing of the CPRI signal sent to the MDE in the CPRI-MUX, the optical-cable delay between REC and RE can be determined without affecting the MDE.

4.2 Radio Transmission/Reception Technology

The structure of the radio transceivers of the REC and RE are shown in **Figure 3**. Using the RE as an example, refer to [1] regarding the structure of the RRE transceiver, and to [3] regarding the structure of the MDE (REC) transceiver in the W-CDMA. As shown in Fig.3, REC and RE functions

*9 **IQ**: The In-phase and quadrature components of a complex digital signal.



CP : Cyclic Prefix
CQI : Channel Quality Indicator
DL : Downlink
FFT : Fast Fourier Transform
IDFT : Inverse Discrete Fourier Transform
IFFT : Inverse FFT
PMI : Precoding Matrix Indicator
RI : Rank Indicator
UL : Uplink

Newly developed equipments
Detailed functional blocks

Figure 3 Radio transmitter/receiver architecture

are clearly allocated, and by gathering all RF functions on the RE side, a variety of connections between REC and RE can be made. Also, changes to parameters such as the radio frequency band or maximum transmission power can be handled easily by changing only the RF functions of the RE.

5. Conclusion

In this article, we have described features of the LTE-system base station equipment used to provide the "Xi" (Crossy) LTE service, as well as technology shared between W-CDMA and LTE systems. By using this shared technology and by reducing energy consumption and cost for the LTE system base station equipment, we have made installation easier and more economical for introduction of the LTE system.

In the future, we plan to further expand this lineup of equipment to support the spread of LTE services nationally.

References

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