

# Outdoor LTE Infrastructure Equipment (eNodeB)

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Fujitsu has developed outdoor Long Term Evolution (LTE) infrastructure equipment (eNodeB) based on the specifications in the 3rd Generation Partnership Project (3GPP). Thanks to the use of highly efficient and highly integrated devices, flexible software configuration technology and simple hardware architecture, this LTE infrastructure equipment is small, lightweight and has a low power consumption. This means it can be deployed easily and efficiently when a number of base stations are installed to cope with heavy traffic load in a mobile network. As a result, this equipment helps reduce capital investment and operating costs in our customers' networks and it also contributes to the environment. This paper describes an outline of this LTE infrastructure equipment and its features.

## 1. Introduction

In recent years, mobile networks have seen a dramatic increase in traffic due to the diffusion of smartphones in Japan. Many operators in Japan and overseas plan to deploy Long Term Evolution (LTE) wireless base station equipment, which makes it possible to utilize frequencies very efficiently, in large volume to respond to a rapid increase in traffic. From the viewpoint of the locations of base stations, equipment with a small footprint that can be easily installed in various places as shown in **Figure 1** is desired. Fujitsu has cultivated assets through the development of W-CDMA and LTE for mobile operators such as NTT DOCOMO. Taking advantage of such assets, it has developed at an early date small and lightweight outdoor LTE infrastructure equipment (eNodeB), which is flexible in terms of where it can be installed.

This paper describes an outline of the eNodeB.

## 2. Key technologies to support LTE

LTE is the standard for wireless communications specified by the 3rd Generation Partnership Project (3GPP), a standardization organization, as 3GPP Release 8.<sup>1)</sup>

LTE concerns a wireless communication system optimized for packet services and realizes high throughput, low latency and highly efficient frequency utilization.

### 1) System optimized for packet services

LTE is a wireless communication system that handles voice calls, which require real-time processing, as IP packet data (Voice over IP), in addition to Internet and e-mail.

### 2) Simplification of network architecture

With LTE, eNodeB is equipped with a wireless access control feature and directly connected to a core network. With a reduced number of layers of equipment that constitutes a wireless access network, this system is simplified as compared with the existing third-generation mobile communication systems. As a result, this system enables low latency for data transfer and

hand-over.

- 3) Wireless access technology robust in multi-path environment

As wireless access systems, LTE uses orthogonal frequency division multiple access (OFDMA) for downlinks and single carrier-frequency division multiple access (SC-FDMA) for uplinks. OFDMA incorporates a mechanism to suppress delayed signal interference by using a cyclic prefix (CP) in a transmission signal format. This makes it robust in a multi-path environment. As with OFDMA, SC-FDMA also uses a CP and is useful in a multi-path environment. In addition, the reduced peak-to-average power ratio (PAPR) means it can effectively reduce the power consumption of terminals.

- 4) Adaptive modulation according to communication quality

For modulation, LTE uses three schemes: quadrature phase shift keying (QPSK), 16

quadrature amplitude modulation (16QAM) and 64 quadrature amplitude modulation (64QAM). Adaptive modulation and coding (AMC) is achieved by combining them with multiple error correction coding rates. By using AMC, the modulation scheme can be dynamically switched according to the quality of communication between eNodeB and user equipment (UE) so as to optimize the transmission capacity.

- 5) Antenna technology to realize high throughput

LTE adopts multiple input multiple output (MIMO) as the antenna technology. MIMO is a spatial multiplexing transmission technology, in which multiple antennas are used to transmit and receive different data, and  $2 \times 2$  MIMO allows transmission with approximately twice as much throughput.

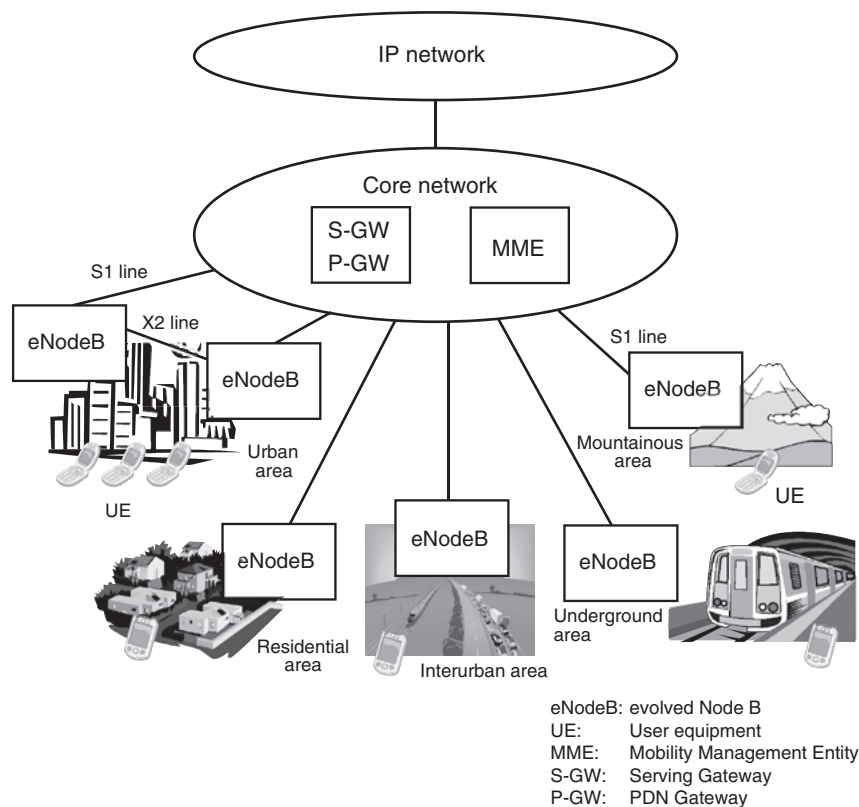


Figure 1  
Configuration of LTE system.

### 3. eNodeB

#### 3.1 Equipment configuration

An eNodeB is composed of one baseband unit (BBU) and up to three remote radio heads (RRHs) that can be connected. To connect the BBU and each RRH, an optical interface compliant with the common public radio interface (CPRI)<sup>2)</sup> specification, which is standard, is used. The specifications of eNodeB are shown in **Table 1** and its configuration in **Figure 2**.

##### 1) BBU

The BBU is responsible for digital baseband signal processing, termination of S1 line used for

connecting with a core network, termination of X2 line used for connecting with the neighboring eNodeB, call processing and monitoring control processing. IP packets received from the core network are modulated into digital baseband signals and transmitted to the RRH(s). The digital baseband signals received from the RRH(s) are demodulated and IP packets are transmitted to the core network.

##### 2) RRH

An RRH transmits and receives wireless signals. An RRH converts the digital baseband signals from BBU that have been subjected to protocol-specific processing into radio frequency (RF) signals and power-amplifies them to transmit to UE. The RF signals received from UE are amplified and converted to digital baseband signals for transmission to the BBU.

**Figure 3** shows an external view of the BBU and RRH.

Table 1  
eNodeB equipment specifications.

Item	Specifications
Radio frequency band	Band4, Band9, Band17
Bandwidth	5, 10, 15, 20 MHz
Access scheme	Downlink: OFDMA Uplink: SC-FDMA
Antenna technology	Downlink: $2 \times 2$ MIMO Uplink: $1 \times 2$ SIMO
No. of sectors	6 sectors max.
Maximum transmission power	60 W (30 W + 30 W)
Maximum transmission rate (per sector)	Downlink: 150 Mb/s Uplink: 50 Mb/s
S1/X2 line interface	1000Base-SX, 1000Base-T
Mobile environment	Up to 350 km/h
Equipment size	BBU: 20 L max. RRH: 20 L max.

SIMO: Single input multiple output

#### 3.2 Architecture

To reduce the size, weight and power consumption, eNodeB is designed to integrate the multiple cards that are conventionally included in the configuration to achieve a simple architecture. As a result, the number of components and signal lines of interfaces between cards have been significantly reduced.

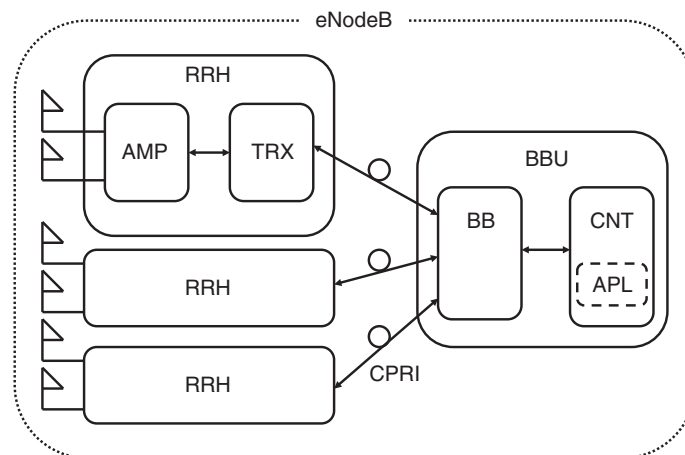


Figure 2  
eNodeB hardware architecture.



Figure 3  
Appearance of eNodeB equipment.

The following describes the respective functional parts of eNodeB shown in Figure 2.

1) CNT

The CNT is a functional part that performs IP layer protocol processing, call control processing, operations, administration and maintenance (OAM) processing, S1/X2 line termination processing, network address translation (NAT) processing, band control processing and also collection of failure information from other functional parts and equipment failure monitoring processing. This functional part is realized by devices such as a high-performance CPU, communications processor and field programmable gate array (FPGA).

The application software (APL) installed in the CNT is compliant with the standard specifications established in 3GPP Release 8. It is responsible for call control processing including cell lock and radio admission control and OAM processing such as performance management, cell supervision and call trace. An interface in view of possible future extension such as self-organizing network (SON), which automates the configuration and operation of eNodeB, is also provided.

2) BB

Performs protocol processing for each of the RLC, PDCP, MAC and PHY layers. The BB is a functional part responsible for digital baseband processing including the LTE-specific MIMO processing, multilevel modulation, OFDMA processing, SC-FDMA processing, AMC processing, H-ARQ processing, power control processing and inter-cell interference control. This functional part is realized by a high-performance digital signal processor (DSP) and FPGA. This allows functional enhancement according to the future release of 3GPP standardized specifications by means of a software download.

3) TRX

This functional part takes charge of wireless signal processing including distortion compensation processing, D-A conversion and A-D conversion of transmission signals. TRX is realized by a high-performance CPU and FPGA.

4) AMP

This functional part amplifies the transmission power of wireless signals. The AMP consists of RF devices such as a monolithic microwave integrated circuit (MMIC).

### 3.3 Features

Major features of eNodeB include the following:

- 1) Small, lightweight and low power consumption

High-efficiency amplifiers based on digital pre-distortion (DPD), a distortion compensation technology, and highly integrated devices have been adopted. In addition, the number of parts has been reduced by revising the architecture. This has reduced the size, weight, and power consumption of the equipment and has realized natural air cooling for it.

- 2) Flexible installation

The BBUs and RRHs developed for outdoor use can be easily installed on utility poles and walls. They can also be installed separately in different locations.

- 3) Flexible equipment configuration

The most suitable hardware and software can be combined to flexibly configure the equipment according to the system requirements (bandwidth and number of sectors) desired by the customer.

- 4) Easy maintenance

Additions and changes to the functions can be easily made by a remote software update. An autonomous maintenance diagnostic function is provided to allow failed parts to be promptly

identified. When equipment failure occurs, the downtime can be minimized by reducing some of the functions and continuing to operate the system.

- 5) Environmental measures

As an approach to environmental measures other than reducing the power consumption of the equipment, energy saving, which is one SON solution anticipated for adoption, is realized.

## 4. Interference control and green technology

High throughput performance and low power consumption are required of LTE wireless base stations. For that reason, the eNodeB is equipped with interference control and green features, which are described below.

- 1) Inter-cell interference coordination (ICIC) feature

ICIC is a feature in which neighboring eNodeBs autonomously assign wireless resources of different frequencies. In this way, radio wave interference, generated when radio signals of the same frequency are used at the boundary with the neighboring cell, can be avoided. This improves the throughput of the terminals located at the cell boundary. **Figure 4** illustrates an outline of ICIC. For details of ICIC, see “Inter-Cell Interference Coordination (ICIC)

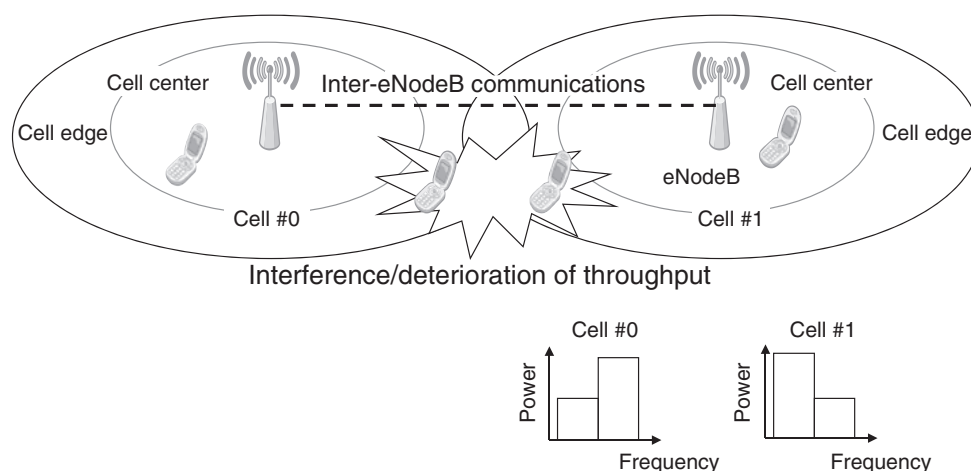


Figure 4  
Outline of ICIC.

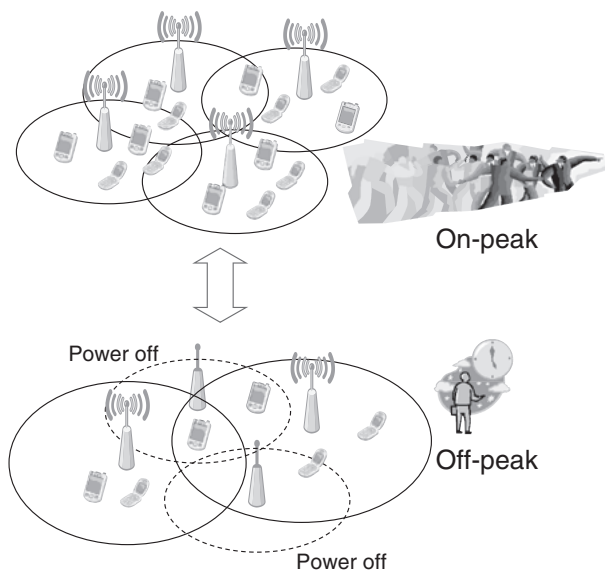


Figure 5  
Outline of energy saving.

Technology” contained in this special issue.

## 2) Green features

The eNodeB is equipped with the following green features.

- Power consumption/temperature monitoring feature

The eNodeB has a feature to monitor the power consumption and temperature of the equipment. The monitored information is used to centrally manage (visualize) the power consumption and CO<sub>2</sub> emissions of the entire network devices.

- Remote power on/off feature (energy saving)

The eNodeB has a feature to remotely power the equipment on and off according to the dynamically changing traffic conditions. This raises prospects for a reduced power consumption in the nighttime, when traffic decreases.

**Figure 5** shows an outline of energy saving.

## 5. Conclusion

Fujitsu has realized small and lightweight outdoor LTE infrastructure equipment featuring low power consumption. It has achieved this by making use of its original high-efficiency amplifier technology and highly integrated devices, adopting a flexible equipment configuration that takes advantage of software and use of a simple architecture that allows hardware to be scaled down. The equipment is provided with green and interference control features.

The features of this equipment can be efficiently deployed to handle the future increase of mobile wireless traffic and contribute to the reduction of capital investment and operational costs of customers. Fujitsu is committed to making continued efforts to promptly fulfill the requests of customers and society and realizing high-value products.

## References

- 1) 3GPP TS36.300 V8.12.0.  
<http://www.3gpp.org/ftp/Specs/html-info/36300.htm>
- 2) CPRI Specification V4.2.  
[http://www.cpri.info/downloads/CPRI\\_v\\_4\\_2\\_2010-09-29.pdf](http://www.cpri.info/downloads/CPRI_v_4_2_2010-09-29.pdf)



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