SAMSUNG

LTE eNB
System Description

Describes an overview of the Samsung system, working, and all major functionalities.

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Radio Access Network

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SNMTC-v3-0312

This manual should be read and used as a guideline for properly installing and/or operating the product. Owing to product variations across the range, any illustrations and photographs used in this manual may not be a wholly accurate depiction of the actual products you are using.
This manual may be changed for system improvement, standardization and other technical reasons without prior notice.
Samsung Networks documentation is available at **http://www.samsungdocs.com**

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Preface

This description describes the characteristics, features and structure of the Samsung LTE eNB.

Conventions in this Document

Samsung Networks product documentation uses the following conventions.

Symbols

Symbol	Description
	Indicates a task.
	Indicates a shortcut or an alternative method.
	Provides additional information.
	Provides information or instructions that you should follow to avoid service failure or damage to equipment.
	Provides information or instructions that you should follow to avoid personal injury or fatality.
	Provides antistatic precautions that you should observe.

Menu Commands

menu | command

This indicates that you must select a command on a menu, where **menu** is the name of the menu, and **command** is the name of the command on that menu.

File Names and Paths

These are indicated by a bold typeface. For example:

Copy **filename.txt** into the **/home/folder1/folder2/bin/** folder.

User Input and Console Screen Output Text

Input and output text is presented in the Courier font. For example,

```
context <designated epc-context-name>
```

CLI commands are presented in bold small caps. For example,

Type the **RTRV-NE-STS** command in the input field.

New and Changed Information

This section describes information that has been added/changed since the previous publication of this manual.

- Technical contents changes.

Revision History

The following table lists all versions of this document.

Document Number	Product/Software Version	Document Version	Publication Date	Remarks
2600-00KGZQGA2	LTE eNB	1.0	April 2017	First Version
2600-00KGZQGA2	LTE eNB	2.0	April 2017	-

Organization of This Document

Section	Title	Description
Chapter 1	Samsung LTE System Overview	• Introduction to Samsung LTE System • Samsung LTE Network Configuration • Intersystem Interface
Chapter 2	LTE eNB Overview	• Introduction to system • Main functions • Specifications
Chapter 3	System Structure	• Hardware structure • Software structure
Chapter 4	Message Flow	• Data Traffic Flow • Network Sync Flow • Alarm Signal Flow • Loading Flow • Operation and Maintenance Message Flow
Appendix	Acronyms	This appendix lists acronyms used in this document.

Personal and Product Safety

Proposition 65 (US Only)

State of California Proposition 65 Warning (US only)

WARNING: This product contains chemicals known to the State of California to cause cancer and birth defects or other reproductive harm.

California USA Only

This Perchlorate warning applies only to primary CR (Manganese Dioxide) Lithium coin cell batteries in the product sold or distributed ONLY in California USA.

Perchlorate Material-special handling may apply. See www.dtsc.ca.gov/hazardous waste/perchlorate.

Chapter 1 Samsung LTE System Overview

Introduction to Samsung LTE System

Samsung LTE system supports 3GPP LTE (hereinafter, LTE) based services.

The LTE is a next generation wireless network system which solves the disadvantages of existing 3GPP mobile systems allows high-speed data service at low cost regardless of time and place.

Samsung LTE system supports Orthogonal Frequency Division Multiple Access (OFDMA) for downlink, Single Carrier (SC) Frequency Division Multiple Access (FDMA) for uplink, and scalable bandwidths for various spectrum allocation and provides high-speed data service. It also provides high-performance hardware for improved system performance and capacity and supports various functions and services.

Samsung LTE system is based on the Rel-8 and Rel-9 standards of LTE 3rd Generation Partnership Project (3GPP).

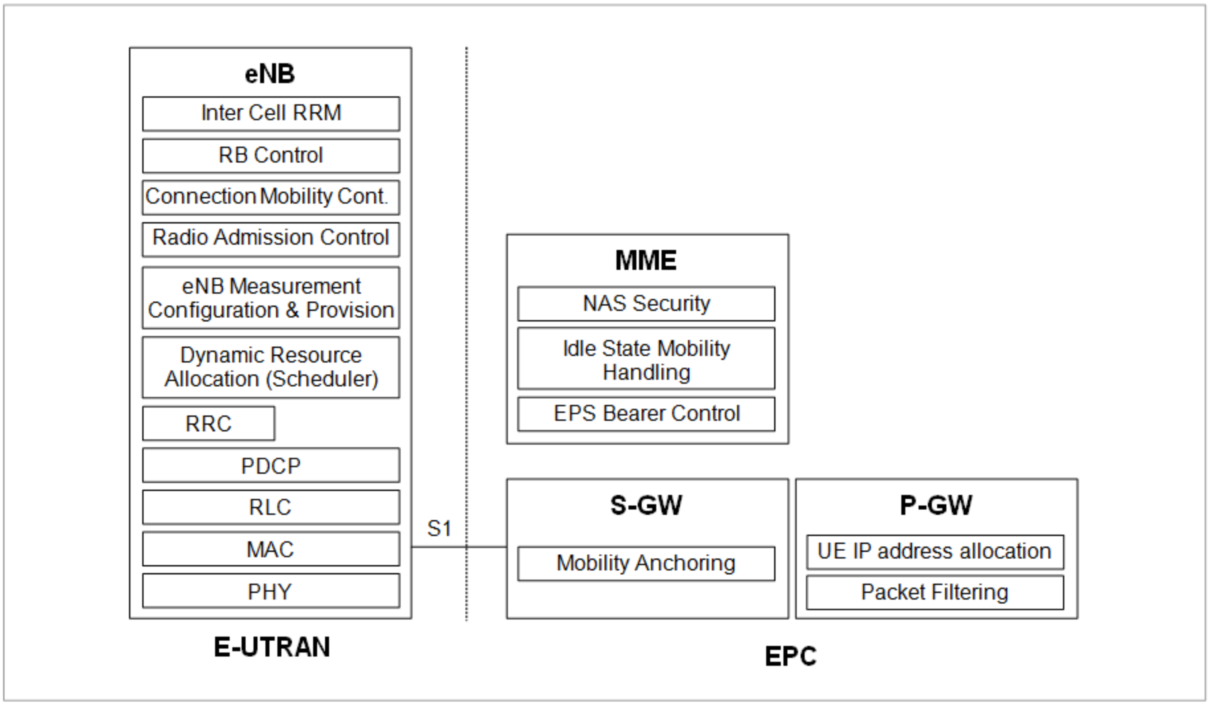
Samsung LTE system consists of evolved UTRAN Node B (eNB), Evolved Packet Core (EPC) and LTE System Manager (LSM).

The eNB exists between EPC and User Equipment (UE). It establishes wireless connections with UE and processes packet calls according to LTE air interface standard. The eNB manages UE in connected mode at the Access Stratum (AS) level. The EPC is the system, which is located between eNB and Packet Data Network (PDN) to perform various control functions. The EPC consists of Mobility Management Entity (MME), Serving Gateway (S-GW), and PDN Gateway (P-GW). The MME manages UE in idle mode at the Non-Access Stratum (NAS) level. Also, S-GW and P-GW manages user data at the NAS level and interworks with other networks.

The LSM provides man-machine interface; manages the software, configuration, performance, and failures. Also, it acts as a Self-Organizing Network (SON) server.

The figure below shows the functional distinctions between eNB of E-UTRAN, MME, S-GW, and P-GW according to the 3GPP standard. The eNB has a layer structure and EPC has no layer.

Figure 1. Functional Distinctions of E-UTRAN and EPC



eNB

The eNB is a logical network component of Evolved UTRAN (E-UTRAN), which is located on access side in LTE system.

The eNBs can be interconnected with each other by X2 interface. The eNBs are connected by S1 interface to Evolved Packet Core (EPC).

The wireless protocol layer of eNB is divided into layer 2 and layer 3. The layer 2 is subdivided into Media Access Control (MAC) layer, Radio Link Control (RLC) layer, and PDCP layer, each of which performs independent functions. Also, layer3 has Radio Resource Control (RRC) layer.

The MAC layer distributes air resources to each bearer according to its priority. Also, it performs multiplexing function and HARQ function for the data, which is received from the multiple upper logical channels.

The RLC layer performs the following functions:

- Segments and reassembles the data, which is received from PDCP layer under the size specified by MAC layer
- Requests retransmission to recover if data transmission fails in the lower layer (ARQ)
- Reorders the data recovered by performing HARQ in MAC layer (re-ordering)

The PDCP layer performs the following functions:

- Header compression and decompression
- Encrypts/decrypts user plane and control plane data

- Protects and verifies the integrity of control plane data
- Transmits data including sequence number related function
- Removes data and redundant data based on a timer

The RRC layer performs mobility management within the wireless access network, maintaining and control of Radio Bearer (RB), RRC connection management, and system information transmission, and so on.

MME

The MME interworks with E-UTRAN (eNB) to process the Stream Control Transmission Protocol (SCTP)-based S1 Application Protocol (S1-AP) signalling messages for controlling call connections between MME and eNB. Also, MME process the SCTP-based NAS signalling messages for controlling mobility connection and call connection between UE and EPC.

The MME is responsible for collecting/modifying the user information and authenticating the user by interworking with HSS. It is also responsible for requesting the allocation/release/change of the bearer path for data routing and retransmission with GTP-C protocol by interworking with S-GW.

The MME interworks with 2G and 3G systems, Mobile Switching Center (MSC), and Serving GPRS Support Node (SGSN) for providing mobility and Handover (HO), Circuit Service (CS) fallback, and Short Message Service (SMS).

The MME is responsible for inter-eNB mobility, idle mode UE reachability, Tracking Area (TA) list management, choosing P-GW/S-GW, authentication, and bearer management.

The MME supports mobility during inter-eNB handover and inter-MME handover. It also supports SGSN selection function upon handover to 2G or 3G 3GPP network.

S-GW

The S-GW acts as the mobility anchor during inter-eNB handover and inter-3GPP handover, and routes and forwards user data packets. The S-GW allows the operator to apply application-specific charging policies to UE, PDN or QCI and manages the packet transmission layers for uplink/downlink data.

The S-GW also supports GPRS Tunnelling Protocol (GTP) and Proxy Mobile IP (PMIP) by interworking with MME, P-GW, and SGSN.

PDN Gateway (P-GW)

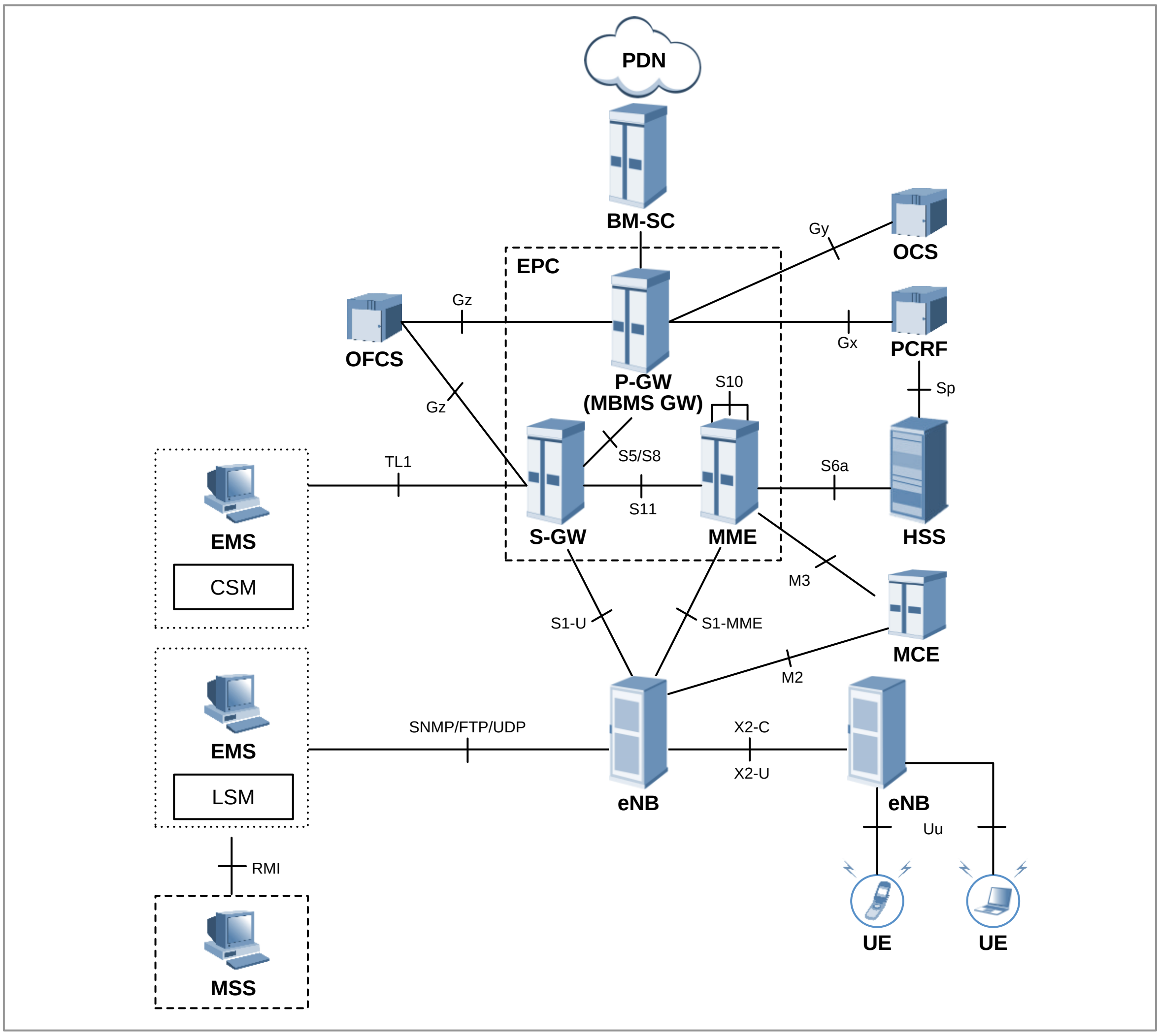
The P-GW is responsible for charging and bearer policy according to the policy and manages charging and transmission rate according to the service level by interworking with PCRF. The P-GW also performs packet filtering for each user, IP address allocation for each UE, and downlink data packet transmission layer management.

Samsung LTE Network Configuration

Samsung LTE system consists of eNB, LSM, and EPC. Also, it comprising multiple eNBs and EPCs (MME, S-GW/P-GW) is a subnet of PDN, which allows User Equipment (UE) to access external networks. In addition, Samsung LTE system provides LSM and self-optimization function for operation and maintenance of eNBs.

The following figure shows Samsung LTE system architecture:

Figure 2. ***Samsung LTE System Architectures***



eNB

The eNB is located between UE and EPC. It processes packet calls by connecting to UE wirelessly according to LTE air standard. The eNB is responsible for transmission and receipt of wireless signals, modulation and demodulation of packet traffic signals, packet scheduling for efficient utilization of wireless resources, Hybrid Automatic Repeat Request (HARQ)/ARQ processing, Packet Data Convergence Protocol (PDCP) for packet header compression, and wireless resources control.

In addition, eNB performs handover by interworking with EPC.

EPC

The EPC is a system, which is located between eNB and PDN. The subcomponents of EPC are MME, S-GW and P-GW, Multimedia Broadcast/Multicast Service Gateway (MBMS GW).

- MME: Processes control messages using the NAS signaling protocol with eNB and performs control plane functions such as UE mobility management, tracking area list management, and bearer and session management.
- S-GW: Acts as the anchor for user plane between 2G/3G access system, LTE system, and manages and changes the packet transmission layer for downlink/uplink data.
- P-GW: Allocates an IP address to UE, acts as the anchor for mobility between LTE and non-3GPP access systems, and manages/changes charging and transmission rate according to the service level.

LTE System Manager (LSM)

The LSM provides user interface for the operator to operate and maintain eNB.

The LSM is responsible for software management, configuration management, performance management and fault management, and acts as a SON server.

Core System Manager (CSM)

The CSM provides user interface for the operator to operate and maintain MME, S-GW, and P-GW.

Master SON Server (MSS)

The MSS interoperates with local SON server as its higher node, making optimized interoperation possible for the multi-LSM. The MSS can work with Operating Support System (OSS) of the service provider who can decide whether to link them.

Home Subscriber Server (HSS)

The HSS is a database management system that stores and manages the parameters and location information for all registered mobile subscribers. The HSS manages key data such as the mobile subscriber’s access capability, basic services and supplementary services, and provides a routing function to the subscribed receivers.

Policy and Charging Rule Function (PCRF)

The PCRF server creates policy rules to dynamically apply the QoS and charging policies differentiated by service flow, or creates the policy rules that can be applied commonly to multiple service flows. The P-GW includes Policy and Charging Enforcement Function (PCEF), which allows application of policy rules received from PCRF to each service flow.

Online Charging System (OCS)

The OCS collects online charging information by interfacing with S-GW and P-GW.

When a subscriber for whom online charging information is required makes a call, P-GW transmits and receives the subscriber's charging information by interworking with OCS.

Offline Charging System (OFCS)

The OFCS collects offline charging information by interfacing with S-GW and P-GW.

The OFCS uses GTP' (Gz) or Diameter (Rf) interface to interface with S-GW and P-GW.

Multi-cell/Multicast Coordination Entity (MCE)

The MCE is located between MME and eNB. It is responsible for session control signaling, admission control, radio resource allocations for eMBMS. M2 and M3 interface is used to interwork with eNB and MME.

Protocol Stack between NEs

The inter-NE protocol stack of the eNB is as follows:

Protocol Stack between UE and eNB

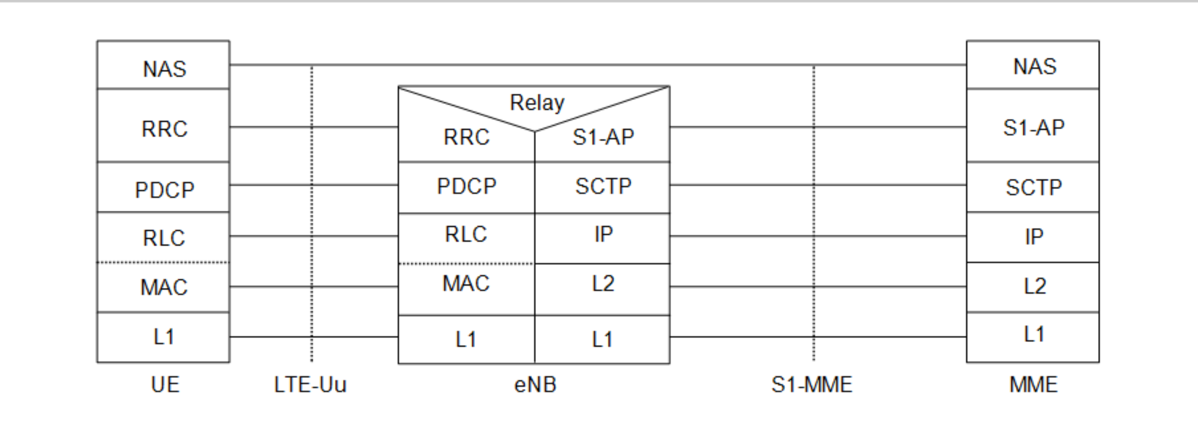
The user plane protocol layer consists of PDCP, RLC, MAC, and PHY layers.

The user plane is responsible for transmission of user data (e.g. IP packets) received from the upper layer. In user plane, all protocols are terminated in eNB.

The control plane protocol layer is composed of the NAS layer, RRC layer, PDCP layer, RLC layer, MAC layer, and PHY layer. The NAS layer is located on the upper wireless protocol. It performs UE authentication between UE and MME, security control, and paging and mobility management of UE in LTE IDLE mode.

In control plane, all protocols except for the NAS signal are terminated in eNB.

Figure 3. ***Protocol Stack between UE and eNB***



Protocol Stack between eNB and EPC

The eNB and EPC are connected physically through FE and GE method, and the connection specification should satisfy LTE S1-U and S1-MME interface.

In user plane, GTP-User (GTP-U) is used as the upper layer of the IP layer; and in Control plane, SCTP is used as the upper layer of the IP layer.

The figure below shows the user plane protocol stack between eNB and S-GW:

Figure 4. Protocol Stack between eNB and S-GW User Plane

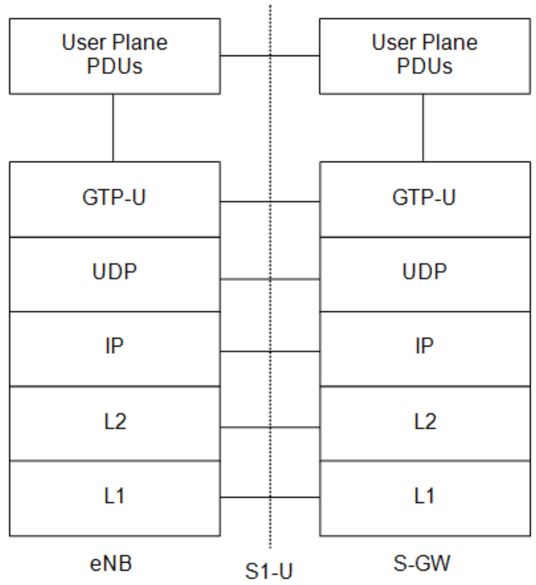
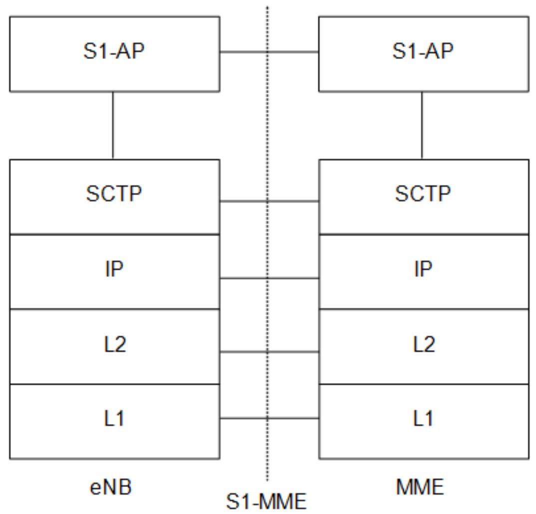


Figure 5. Protocol Stack between eNB and MME Control Plane

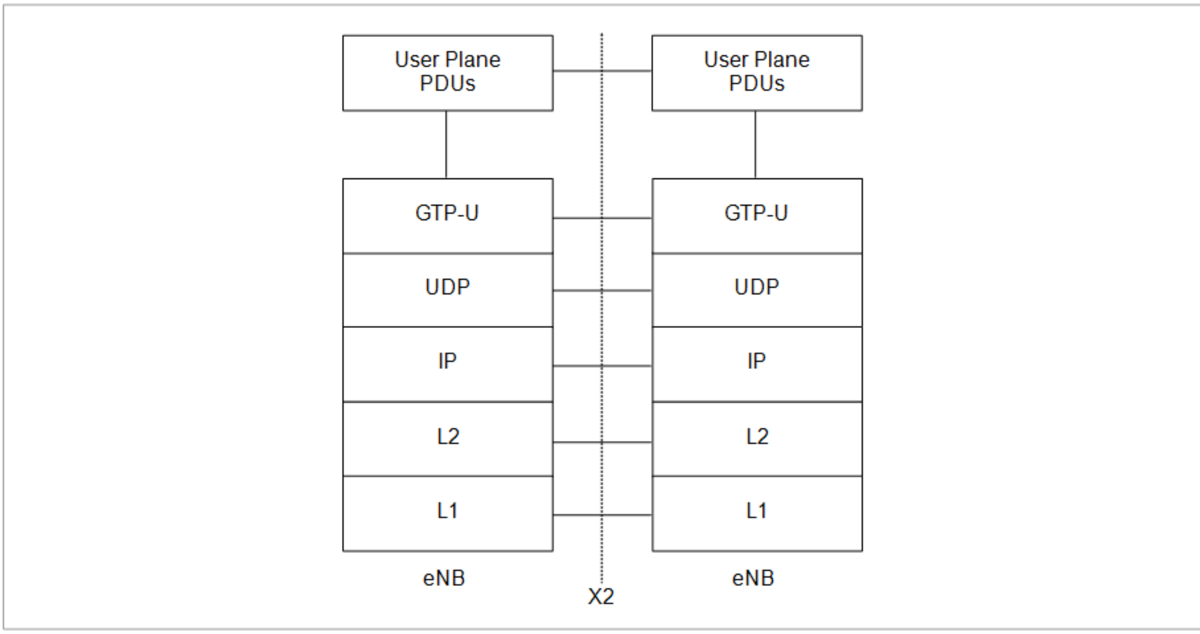


Inter-eNB Protocol Stack

The two eNBs are connected physically through FE and GE method, and the connection specification should satisfy LTE X2 interface.

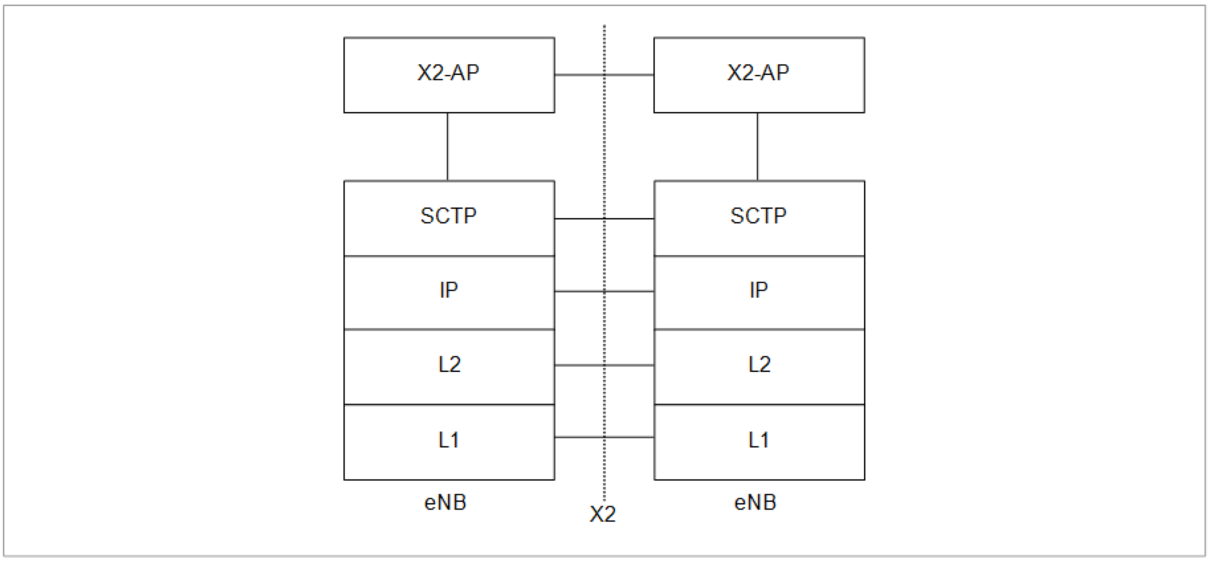
The following figure shows the inter-eNB user plane protocol stack:

Figure 6. Inter-eNB User Plane Protocol Stack



The following figure shows the control plane protocol stack:

Figure 7. Inter-eNB Control Plane Protocol Stack

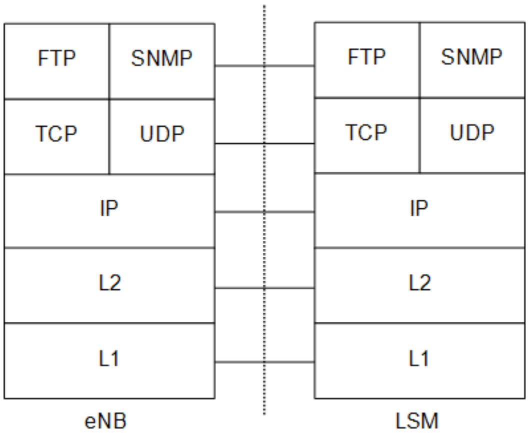


Protocol Stack between eNB and LSM

The FE and GE are used for the physical connection between eNB and LSM, and connection specifications must satisfy FTP/SNMP interface.

The following figure shows the user plane protocol stack between eNB and LSM:

Figure 8. Interface Protocol Stack between eNB and LSM

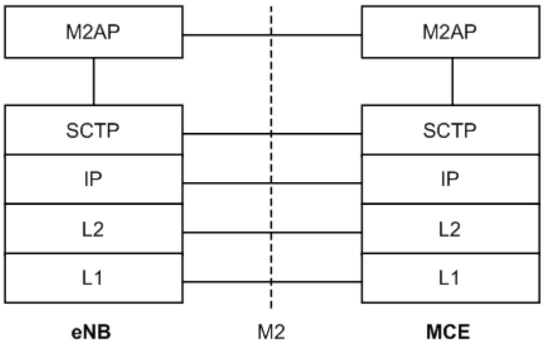


Protocol Stack between eNB and MCE Server

The eNB must provide the interface for the interoperation with the MCE server.

GE is used for physical connection between the eNB and MCE server. The connection specification must satisfy the STCP interface.

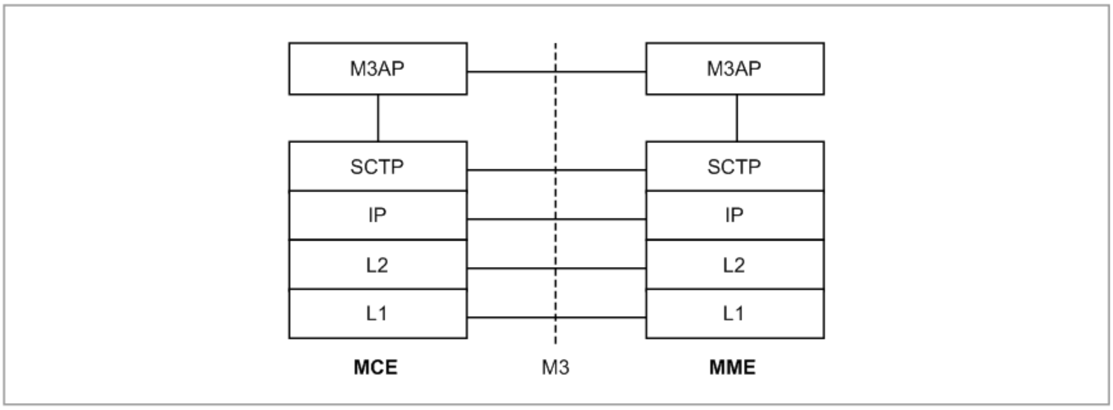
Figure 9. Protocol Stack between eNB and MCE Server



Protocol Stack between MCE Server and MME

GE is used for physical connection between the MME and MCE server. The connection specification must satisfy the STCP interface. The protocol stack between the MCE server and MME is as follows:

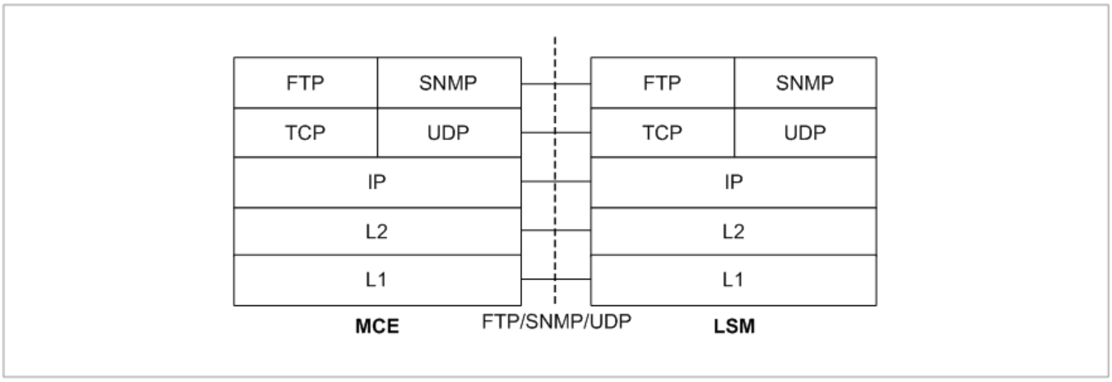
Figure 10. ***Protocol Stack between MCE Server and MME***



Protocol Stack between MCE Server and LSM

GE is used for physical connection between the LSM and MCE server. The connection specification must satisfy the FTP/SNMP/UDP interface. The following diagram shows the interface protocol stack between the MCE server and LSM.

Figure 11. ***Protocol Stack between MCE Server and LSM***



Chapter 2 LTE eNB Overview

Introduction to System

In LTE system, eNB is located between UE and EPC. The eNB provides mobile communications services to subscribers according to LTE air interface standard.

The eNB transmits/receives radio signals to/from UE and processes the modulation and demodulation of packet traffic signals. The eNB is also responsible for packet scheduling and radio bandwidth allocation and performs handover via interface with EPC.

The eNB consists of Digital Unit (DU) and Radio Unit (RU).

The CDU is a digital unit (19-inch shelf) and can be mounted into indoor or outdoor 19-inch commercial rack.

The RRH is a RF integration module consisting of a transceiver, power amplifier, and filter. It transmits and receives traffic, clock information, and alarm/control messages to and from the CDU. The RRH has 4Tx/4Rx, 2Tx/4Rx or 2Tx/2Rx configurations supporting optic CPRI and can be installed on outdoor wall or pole.

The main features of eNB are as follows:

High Compatibility and Interoperability

The eNB complies with the specifications released based on the 3GPP standard.

So, it has high compatibility and interoperability.

High-Performance Modular Structure

The eNB has high-performance with the use of high-performance processors.

It is easy to upgrade hardware and software because of its modular structure.

Support for Advanced RF and Antenna Solutions

The eNB adopts the power amplifier to support wideband operation bandwidth and Multiple Input Multiple Output (MIMO).

Separation of CDU and RRH

The eNB consists of CDU and RRH separately for easy installation and flexible network configuration. In case of connection between CDU and RRH, data traffic signals and OAM information are transmitted/received through the Digital I/Q and C & M interface based on the Common Public Radio Interface (CPRI). Physically, optic cables are used.

The CDU and RRH are supplied DC -48 V DC power from a rectifier respectively.

- Flexible Network Configuration

The RRH is not a standalone device; it operates interfacing with CDU. The RRH is highly flexible in its installation, and helps with setting up a network in a variety of configurations depending on the location and operation method.

- Easy Installation

  The optic interface component that interfaces with CDU and RF signal processing component is integrated into RRH, which becomes a very small and very light single unit. The RRH can be installed on a wall, pole, or floor.

  In addition, as the distance between RRH and antenna is minimized, the loss of RF signals due to the antenna feeder line can be reduced so that the line can provide more enhanced RF receiving performance than the existing rack-type eNB.

- Natural Convection Cooling

  The RRH is designed to discharge heat effectively through natural convection cooling without an additional cooling device. No additional maintenance cost is needed for cooling the RRH.

- Support for Loopback Test between CDU and RRH

  The eNB provides loopback test function to check whether communication is normal on a Digital I/Q and C & M interface between the CDU and RRH.

- Remote Firmware Downloading

  By replacing its firmware, RRH can be upgraded by service and performance. The operator can download firmware to RRH remotely using a simple command from LSM without visiting the local site. As a result, the number of visits is minimized, leading to reduced maintenance costs and system operation with ease.

MBSFN Transmission Support

Since eNB supports Multimedia Broadcast multicast service over a Single Frequency Network (MBSFN) transmission, same data stream of the time synchronized cells are transmitted to the same subcarriers at the same time so that UE can recognize the data transmitted from multiple cells as the data transmitted from a single cell and the interference among the cells can be reduced. The sub-frame of the data stream always uses extended Cyclic Prefix (CP) to prevent interference to the delay spread.

Main Functions

The main functions of LTE eNB are as follows:

- Physical Layer Processing
- Call Processing Function
- IP Processing
- SON Function
- Interfacing with Auxiliary Devices
- Easy Operation and Maintenance

In case of availability and provision schedule of the features and functions described in the system manual, refer to separate documentations.

Physical Layer Processing

The eNB transmits/receives data through the radio channel between EPC and UE.

To do so, eNB provides the following functions:

- OFDMA/SC-FDMA Scheme
- Downlink Reference Signal Creation and Transmission
- Downlink Synchronization Signal Creation and Transmission
- MBSFN Reference Signal Creation and Transmission
- Channel Encoding/Decoding
- Modulation/Demodulation
- Resource Allocation and Scheduling
- Link Adaptation
- HARQ
- Power Control
- ICIC
- MIMO

OFDMA/SC-FDMA Scheme

The eNB performs downlink OFDMA/uplink SC-FDMA channel processing that supports LTE standard physical layer. The downlink OFDMA scheme allows the system to transmit data to multiple users simultaneously using the subcarrier allocated to each user. Depending on the channel status and transmission rate requested by the user, downlink OFDM can allocate one or more subcarriers to a specific subscriber to transmit data.

In addition, when all sub-carriers are divided for multiple users, eNB can select and assign to each subscriber a sub-carrier with the most appropriate features using the OFDMA scheme, thus to distribute resources efficiently and increase data throughput.

In case of uplink SC-FDMA, which is similar to OFDMA modulation and demodulation, a Discrete Fourier Transform (DFT) is applied to each subscriber in the modulation at the transmitting side. An inverse Discrete Fourier Transform (IDFT) is applied for minimizing the Peak to Average Power Ratio (PAPR) at the transmitting side, which allows continuous allocation of frequency resources available for individual subscribers. As a result, eNB can reduce the power consumption of the UE.

Downlink Reference Signal Creation and Transmission

The UE must estimate downlink channel to perform the coherent demodulation on the physical channel in LTE system. The LTE uses OFDM/OFDMA-based methods for transmitting and therefore the channel can be estimated by inserting the reference symbols from the receiving terminal to the grid of each time and frequency. These reference symbols are called downlink reference signals, and there are 2 types of reference signal defined in LTE downlink.

- Cell-specific reference signal: The cell-specific reference signal is transmitted to every subframe across the entire bandwidth of the downlink cell. It is mainly used for channel estimation, MIMO rank calculation, MIMO precoding matrix selection and signal strength measurement for handover.
- UE-specific Reference Signal: The UE-specific reference signal is used for channel estimation for coherent demodulation of DL-SCH transmission where the beamforming method is used. UE-specific means that the reference signal is used for channel estimation of a specified UE only. Therefore, the UE-specific reference signal is used in the resource block allocated for DL-SCH only, which is transmitted to the specified UE.

Downlink Synchronization Signal Creation and Transmission

The synchronization signal is used for initial synchronization when UE starts to communicate with eNB.

There are two types of synchronization signals:

- Primary Synchronization Signal (PSS)
- Secondary Synchronization Signal (SSS)

The UE can obtain cell identity through the synchronization signal. It can obtain other information about cell through the broadcast channel. Since synchronization signals and broadcast channels are transmitted in 1.08 MHz range, which is right in the middle of cell’s channel bandwidth, UE can obtain the basic cell information such as cell ID regardless of the transmission bandwidth of eNB.

MBSFN Reference Signal Creation and Transmission

In the enhanced/evolved Multimedia Broadcast Multicast Services (eMBMS) system, MBSFN reference signal of MBSFN sub-frame in addition to the cell-specific reference signal and UE-specific reference signal used by the existing unicast. These both reference signals are used to estimate the downlink physical channel by inserting the reference symbols that can be recognized by the reception layer MBSFN reference signal.

The MBSFN reference signal is provided in 15 MHz subcarrier spacing in case of extended CP to antenna port number 4.

Channel Encoding/Decoding

The eNB is responsible for channel encoding/decoding to correct the channel errors that occurred on a wireless channel. In LTE, the turbo coding and the 1/3 tail-biting convolutional coding are used. Turbo coding is mainly used for transmission of large data packets on downlink and uplink, while convolutional coding is used for control information transmission and broadcast channel for downlink and uplink.

Modulation/Demodulation

In case of data received over downlink from the upper layer, eNB processes it through baseband of the physical layer and transmits it via a wireless channel.

At this time, to transmit a baseband signal as far as it can go via the wireless channel, the system modulates and transmits it on a specific high frequency bandwidth.

In case of data received over uplink from UE through a wireless channel, eNB demodulates and changes it to baseband signal to perform decoding.

Resource Allocation and Scheduling

To support multiple accesses, eNB uses OFDMA for downlink and SC-FDMA for uplink. By allocating the 2-dimensional resources of time and frequency to multiple UEs without overlay, both methods enable eNB to communicate with multiple UEs simultaneously.

When eNB operates in MU-MIMO mode, the same resource also may be used for multiple UEs simultaneously. Such allocation of cell resources to multiple UEs is called scheduling, and each cell has its own scheduler for this function.

The LTE scheduler of eNB allocates resources to maximize the overall throughput of the cell by considering channel environment of each UE, the data transmission volume required, and other QoS elements. In addition, to reduce interferences with other cells, eNB can share information with the schedulers of other cells over the X2 interface.

Link Adaptation

The wireless channel environment can become faster or slower, better or worse depending on various factors. The system is capable of increasing the transmission rate or maximizing the total cell throughput in response to the changes in the channel environment, and this is called link adaptation.

In particular, Modulation Coding Scheme (MCS) is used for changing the modulation method and channel coding rate according to the channel status. If channel environment is good, MCS increases the number of transmission bits per symbol using a high-order modulation, such as 256 QAM. If channel environment is bad, it uses a low-order modulation, such as QPSK and a low coding rate to minimize channel errors.

In addition, in the environment where MIMO mode can be used, eNB operates in MIMO mode to increase the peak data rate of subscribers and can greatly increase the cell throughput.

If the channel information obtained is incorrect or modulation method of higher order or higher coding rate than the given channel environment is used, errors may occur.

In such cases, errors can be corrected by HARQ function.

H-ARQ

The H-ARQ is a retransmission method in the physical layer, which uses the stop-and-wait protocol. The eNB provides H-ARQ function to retransmit or combine frames in the physical layer so that the effects of wireless channel environment changes or interference signal level changes can be minimized, which results in throughput improvement.

The LTE uses Incremental Redundancy (IR)-based H-ARQ method and regards the Chase Combining (CC) method as a special case of the IR method.

The eNB uses asynchronous method for downlink and synchronous method for uplink.

Power Control

When transmitting a specific data rate, too high power level may result in unnecessary interferences and too low power level may result in an increased error rate, causing retransmission or delay. Unlike in other schemes such as CDMA, the power control is relatively less important in LTE. Nevertheless, adequate power control can improve performance of LTE system.

In LTE uplink, SC-FDMA is used so that there are no near-far problems that occur in CDMA. However, the high level of interference from nearby cells can degrade the uplink performance.

Therefore, UE should use adequate power levels for data transmission in order not to interfere with nearby cells. Likewise, the power level for each UE could be controlled for reducing the inter-cell interference level.

In LTE downlink, eNB can reduce inter-cell interference by transmitting data at adequate power levels according to the location of UE and MCS, which results in improvement of the entire cell throughput.

Inter-Cell Interference Coordination (ICIC)

Since UEs within a cell in LTE use orthogonal resources with no interference between UEs, there is no intra-cell interference.

However, if different UEs in neighbor cells use the same resource, interference may occur. This occurs more seriously between UEs located on the cell edge, resulting in serious degradation at cell edge.

A scheme used to relieve such inter-cell interference problem on the cell edge is ICIC.

The ICIC allows interference signals to be transmitted to other cells in the cell edge area in as small an amount as possible by allocating a basically different resource to each UE that belongs to a different cell and by carrying out power control according to UE's location in the cell.

The eNBs exchange scheduling information with each another via X2 interface for preventing interferences by resource conflicts at cell edges. If the interference of a neighbor cell is too strong, the system informs other system to control strength of the interference system.

The ICIC scheme is used to improve the overall cell performance.

MIMO

The LTE eNB supports 2Tx/2Rx, 2Tx/4Rx or 4Tx/4Rx MIMO by default using multiple antennas.

To support multiple antennas, the baseband module of the eNB channel card processes MIMO, and each path of the RF is processed separately. The LTE eNB provides high-performance data services by supporting several types of MIMO.

Call Processing Function

Cell Information Transmission

In a serving cell, eNB periodically transmits a Master Information Block (MIB) and System Information Blocks (SIBs), which are system information, to allow UE that receives them to perform proper call processing.

Call Control and Air Resource Assignment

The eNB allows UE to be connected to or disconnected from the network.

When UE is connected to or released from the network, eNB transmits and receives the signaling messages required for call processing to and from UE via the Uu interface, and to and from EPC via the S1 interface.

When UE connects to the network, eNB performs call control and resource allocation required for service. When UE is disconnected from the network, eNB collects and releases the allocated resources.

In case of more information on the handover procedure, refer to 'Message Flow' section below.

Admission Control (AC)

The eNB provides capacity-based admission control and QoS-based admission control for a bearer setup requested from EPC so that the system is not overloaded.

- Capacity-based admission control

  There is a threshold for the maximum number of connected UEs (new calls/handover calls) and bearers that can be allowed in eNB. Call admission is determined depending on whether the connected UEs and bearers exceed the thresholds.

- QoS-based admission control

  The eNB determines whether to admit a call depending on the estimated PRB usage of the newly requested bearer, the PRB usage status of the bearers in service, and the maximum acceptance limit of the PRB (per bearer type, QCI, and UL/DL).

RLC ARQ

The eNB performs ARQ function for the RLC Acknowledged Mode (AM) only.

When receiving and transmitting the packet data, RLC transmits SDU by dividing it into units of RLC PDU at the transmitting side. Also, the packet is retransmitted (forwarded) according to ARQ feedback information received from the receiving side for increased reliability of the data communication.

QoS Support

The eNB receives QoS Class Identifier (QCI) in which QoS characteristics of the bearer are defined and GBR, MBR, and the Aggregated Maximum Bit Rate (UE-AMBR) from the EPC. It provides QoS for the wireless section between UE and eNB and the backhaul section between eNB and S-GW.

Through air interface, it performs retransmission to satisfy the rate control according to GBR/MBR/UE-AMBR values, priority of bearer defined in QCI, and scheduling considering packet delay budget, and the Packet Loss Error Rate (PLER).

Through backhaul interface, it performs QCI-based packet classification, QCI to DSCP mapping, and marking for the QoS. It provides queuing depending on mapping results, and each queue transmits packets to the EPC according to a strict priority, and so on.

In Element Management System (EMS), besides to the QCI predefined in the specifications, operator-specific QCI, and QCI-to-DSCP mapping can be set.

SYNC Handler Function

The eNB provides Synchronization (SYNC) protocol function to the backhaul section between eNB and MBMS-GW for each Temporary Mobile Group ID (TMGI) of the MBMS bearer from MME.

IP Processing

IP QoS

The eNB can provide the backhaul QoS when communicating with EPC by supporting the Differentiated Services (DiffServ).

The eNB supports 8 classes of DiffServ and mapping QoS between services classes of the user traffic received from MS and DiffServ classes. In addition, eNB supports mapping the services classes based on Differentiated Services Code Points (DSCP) to the 802.3 Ethernet MAC service classes.

IP Routing

Since eNB provides multiple Ethernet interfaces, it stores in the routing table information on which Ethernet interface of IP packets will be routed to. The routing table of eNB is configured by the operator. The method for configuring routing table is similar to the standard router configuration method.

The eNB supports static routing settings, but does not support dynamic routing protocols such as Open Shortest Path First (OSPF) or Border Gateway Protocol (BGP).

IP Multicast Routing

The eNB provides multiple Ethernet interfaces, and it stores information on which Ethernet interface IP packets will be routed to the routing table.

The routing table of eNB is configured by the operator in the similar way to the router standard configuration. IP multicast is based on PIM and IGMPv2 SSM.

Ethernet/VLAN Interface

The eNB provides Ethernet interfaces and supports the static link grouping, Virtual Local Area Network (VLAN), and Ethernet CoS functions that comply with IEEE 802.3ad for Ethernet interfaces. The MAC bridge function defined in IEEE 802.1D is not supported.

The eNB allows multiple VLAN IDs to be set for an Ethernet interface. To support Ethernet CoS, it maps DSCP value of IP header to the CoS value of the Ethernet header for Tx packets.

SON Function

The SON function supports the self-configuration, self-establishment and self-optimization function.

Self-Configuration and Self-Establishment

Self-configuration and self-establishment enable automatic setup of radio parameters and automatic configuration from system ‘power-on’ to ‘in-service’, which minimizes the effort in installing the system.

The detailed functions are as follows:

- Self-Configuration
  - Self-configuration of Initial Physical Cell Identity (PCI)
  - Self-configuration of initial neighbor information
  - Self-configuration of initial Physical Random Access Channel (PRACH) information
- Self-Establishment
  - Automatic IP address acquisition
  - Auto OAM connectivity
  - Automatic software and configuration data loading
  - Automatic S1/X2 setup
  - Self-test

Self-Optimization

- PCI auto-configuration

  The SON server of LSM is responsible for allocating initial PCI in the self-establishment procedure of a new eNB, detecting a problem automatically, and selecting, changing, and setting a proper PCI when a PCI collision/confusion occurs with the neighbor cells during operation.

- Automatic Neighbor Relation (ANR) optimization

  The ANR function minimizes the network operator's effort to maintain optimal NRT by managing the NRT dynamically depending on grow/degrow of the neighbor cells. This function automatically configures the initial NRT of each eNB and recognizes environment changes, such as cell grow/degrow or new eNB installation during operation to maintain the optimal NRT. In other words, ANR function updates the NRT for each eNB by automatically recognizing topology changes such as new neighbor cell or eNB installation/remove and adding or removing the Neighbor Relation (NR) to or from the new neighbor cell.

- Mobility robustness optimization

  The mobility robustness optimization function is the function for improving handover performance in eNB by recognizing the problem that handover is triggered at the incorrect time (for example, too early or too late) before, after, or during handover depending on UE mobility, or handover is triggered to the incorrect target cell (handover to the wrong cell), and then by optimizing the handover parameters according to the reasons for the problem.

- Random Access Channel (RACH) optimization

  The RACH Optimization (RO) function minimizes the access delay and interference through dynamic management of the parameters related to random access. The RO function is divided into initial RACH setting operation and operation for optimizing parameters related to the RACH. The initial RACH setting operation is for setting the preamble signatures and the initial time resource considering the neighbor cells. The operation for optimizing parameters related to the RACH is for estimating the RACH resources, such as time resource and subscriber transmission power required for random access, that change depending on time, and for optimizing the related parameters.

- Mobility Load Balancing (MLB)

  The MLB function monitors the cell's load. If the load status satisfies the MLB execution condition specified by the operator, this function moves a part of the traffic to a neighbor cell through network-initiated HO. The MLB execution condition is divided into load equalization condition among multiple carriers, and the overload condition of a cell.

Easy Operation and Maintenance

The eNB interworks with management systems such as LSM, Web-EMT, and CLI. It provides the following maintenance functions:

- System initialization and restart
- System configuration management
- Management of fault/status/diagnosis for system resources and services
- Management of statistics on system resources and various performance data
- Security management for system access and operation

Graphics and Text Based Console Interfaces

The LSM manages all eNBs in the network using Database Management System (DBMS). The eNB also interworks with console terminal to allow the operator to connect directly to the Network Element (NE), rather than through LSM, and perform the operations and maintenance.

The operator can use the graphics-based console interface (Web-EMT, Web-based Element Maintenance Terminal) or the text-based Command Line Interface (CLI) according to user convenience and work purposes. Also, they can access the console interfaces without additional software. In case of Web-EMT, the operator can log in to the system using Internet Explorer. In case of CLI, the operator can log in to the system using telnet or Secure Shell (SSH) in the command window.

The operator can perform the management of configuration and operational information, management of fault and status, and monitoring of statistics and so on. To grow/degrow resources or configure a neighbor list that contains relation of multiple NEs, the operator needs to use the LSM.

Operator Authentication Function

The eNB provides the authentication and privilege management functions for the system operators.

The operator accesses eNB using their account and password via the CLI.

At this time, eNB allows the operator an operation privilege by the operator's level.

The eNB also logs the access successes and failures for CLI, login history, and so on.

Highly-Secured Maintenance

The eNB supports the Simple Network Management Protocol (SNMP) and SSH File Transfer Protocol (SFTP) for security during communications with LSM, and Hypertext Transfer Protocol over SSL (HTTPs) and Secure Shell (SSH) during communications with the console terminal.

Online Software Upgrade

When a software package is upgraded, EPC can upgrade the existing package while it is still running.

The package upgrade is done by downloading a new package → activating of the new package. The download and activation of a new package is performed using the Download and Activation menu of LSM GUI.

When upgrading the package, the service stops temporarily at the ‘change to the new package’ step because the existing process needs to be stopped so that the new process can start. Since the operating system does not need to be restarted, the service can be resumed within several minutes. After upgrading the software, the eNB updates the package, which is stored in the internal non-volatile storage.

Call Trace

The eNB supports the call trace function for a specific UE.

The operator can enable trace for a specific UE through MME. The trace execution results such as signaling messages are transmitted to LSM.

OAM Traffic Throttling

The eNB provides the operator with the function for suppressing OAM-related traffic that can occur in the system using the operator command. At this time, the target OAM-related traffic includes the fault trap messages for alarm reporting and the statistics files generated periodically.

In case of fault trap messages, the operator can suppress generation of alarms for the whole system or some fault traps using the alarm inhibition command, consequently allowing the operator to control the amount of alarm traffic that is generated. In case of statistics files, the operator can control the amount of statistics files by disabling the statistics collection function for each statistics group using the statistics collection configuration command.

Specifications

Key Specifications

The key specifications of eNB are as follows:

Table 1. Key Specifications

Category	Specification
Technology	3GPP Rel. 13
Duplex type	FDD
Operating Frequency	• DL: 746 to 756 MHz • UL: 777 to 787 MHz
Channel Bandwidth	10 MHz 4Tx/4Rx, 2Tx/4Rx or 2Tx/2Rx per RRH
CDU-RRH Interface	Max. 36 Optic CPRI
Capacity	Max. 12 cells @ 10/20MHz 4Tx/4Rx, 2Tx/4Rx or 2Tx/2Rx Max. 18,000 RRC connected UEs Max. 54,000 bearers *) Per cell ○ Max. 600 RRC connected UEs ○ Max. 1,800 bearers
Backhaul Links	• 100/1000 Base-T Copper (RJ-45) 1 Port • 1000 Base-X SFP 1 Port • 1000 Base-X/10 GBase-SR/LR SFP+ 1 Port
Input Power	-48 V DC
Clock sync	IEEE1588v2, GNSS

Input Power

The following table shows the power specifications for LTE eNB. The LTE eNB complies with UL60950 safety standard for electrical equipment. If the operator needs AC power for the system input voltage, it can be supplied using an additional external rectifier (installed by the provider).

Table 2. Input Power

Category	Specifications
CDU	-48 V DC (-40.5~-57 V DC)
RRH	-48 V DC (-38~-57 V DC)

Dimensions and Weight

The following table shows the dimensions and weight of LTE eNB:

Table 3. ***Dimensions and Weight***

Category		Specifications
Dimensions (W × D × H, mm)	CDU	434 × 385 × 88
	RRH	320 × 320 × 151
Weight (kg)	CDU	15 or less (based on full configuration)
	RRH	Approx. 17

GPSR Specifications

The following table shows the specifications of LTE eNB's GPS Receiver (GPSR):

Table 4. ***GPSR Specifications***

Category	Specifications
Received Signal from GPS	GPS L1 Signal
Accuracy/Stability (ppm)	0.05

Ambient Conditions

The following table shows the operating temperature, humidity level and other ambient conditions and related standard of CDU:

Table 5. ***CDU Ambient Conditions***

Category	Specifications
Temperature Condition (°C) [a)]	0~50
Humidity Condition [a)]	5~90 %RH, non-condensing, not to exceed 30 g/㎥ absolute humidity.
Altitude (m)	-60~1,800 (Telcordia GR-63-CORE)
Earthquake	Telcordia Earthquake Risk Zone4 (Telcordia GR-63-CORE)
Vibration	• Vibration in Use ○ 5~100 Hz, 0.15 grms (Telcordia GR-63-CORE) • Transportation Vibration ○ 5~200 Hz, 0.89 grms (Telcordia GR-63-CORE)
Sound Power Level	Maximum 78 dB at 27°C (Telcordia GR-63-CORE Issue 4, Section 4.6 Acoustic Noise, Sound Power Level)
EMC	• FCC Title 47 CFR Part 15 • GR-1089-CORE
Safety	UL 60950-1
[a)] Temperature and humidity are measured at 1.5 m above the floor and at 400 mm away from the front panel of the equipment.	

The following table shows the ambient conditions and related standard of RRH:

Table 6. ***LTE FDD 4Tx/4Rx RU Specification (RFD01P-13A)***

Item	RFD01P-13A

Item	RFD01P-13A
Operating Temperature (°C)	-40~55 (without solar load)
Operating Humidity	5~100 % RH, condensing, not to exceed 30g/㎥ absolute humidity
Altitude (m)	-60~1,800 (Telcordia GR-63-CORE)
Earthquake	Telcordia Earthquake Risk Zone4 (Telcordia GR-63-CORE)
Vibration	• Office Vibration (Section 4.4.4) • Transportation Vibration (Section 4.4.5)
Noise	Fanless (natural convection cooling)
EMC	FCC Title 47 CFR Part 15
Safety	UL 60950-1 2nd Ed.
RF	FCC Title 47 CFR Part 27

Chapter 3 System Structure

Hardware Structure

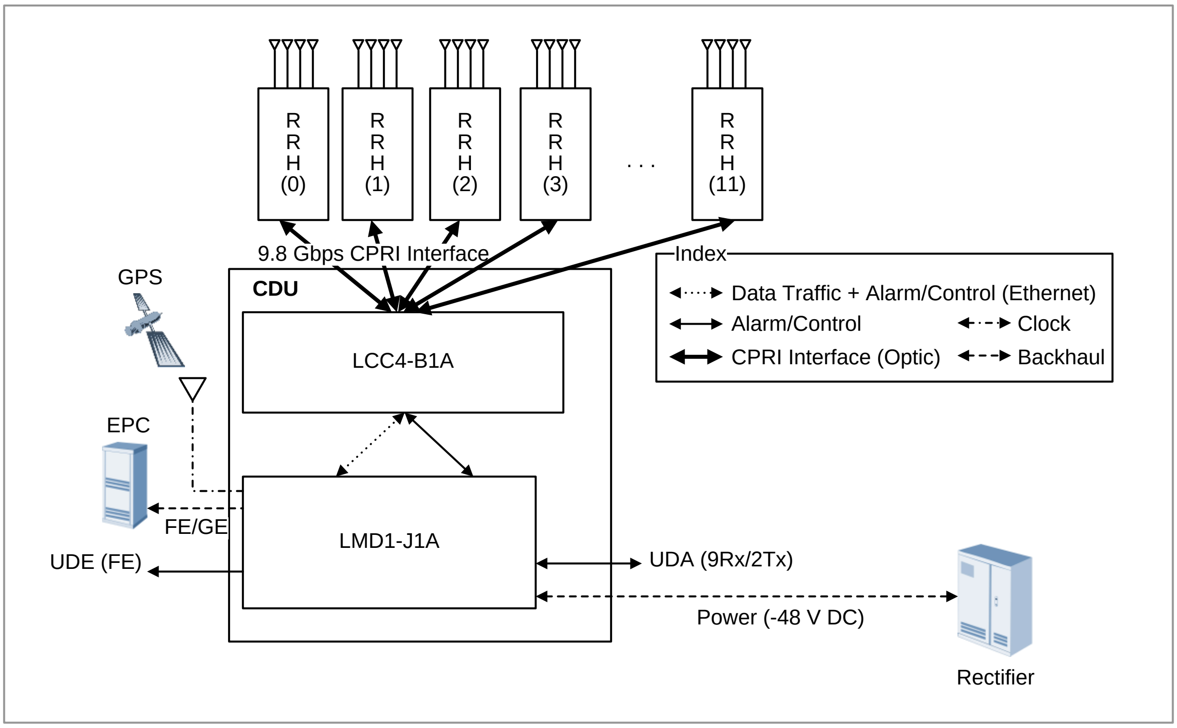
The LTE eNB is the system that consists of Cabinet DU (CDU) which is a common platform DU, and Remote Radio Heads (RRH) which is an RU.

CDU

The CDU is connected to RRH through CPRI, and it can provide up to 4 carrier/3 sector service.

The following figure shows the configuration of LTE eNB:

Figure 12. ***Internal Configuration of eNB***



Up to three channel card can be mounted in a CDU and LCC4 has a capacity of 1 carrier/3 sector per board by default.

The four slots of CDU are multi-board type slots where LMD1 carries out the main processor function, network interface function, clock generation and distribution function, provider-requested alarm processing, and so on. The LCC4-B1A carries out the modem function. The power module, fan, and air filter are also installed.

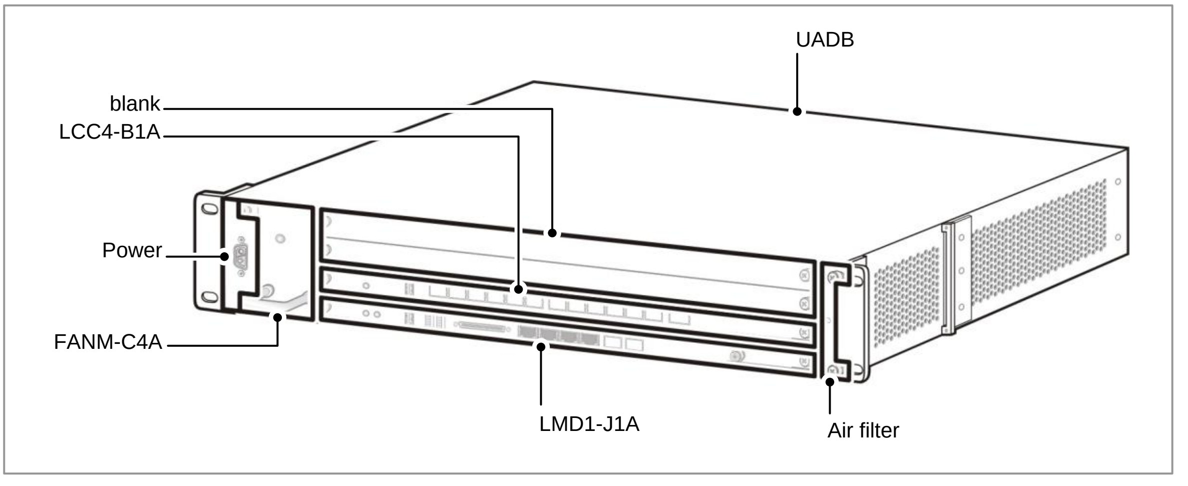
The RRH is an RF integration module consisting of a transceiver, power amplifier, and filter. It sends and receives traffic, clock information, and alarm/control messages to and from LCC4. It has 4Tx/4Rx, 2Tx/4Rx or 2Tx/2Rx configurations with optic CPRI support.

Each RRH is connected an optic CPRI; up to 12 RRHs can be connected to LCC4.

The CDU is the multi-board type DU in which LMD1 that carries out the main processor function, network interface function, and clock creation and distribution function. The LCC4 carries out the modem function are mounted. It consists of the power module (PDPM), FANM-C4A, and air filter. The CDU is mounted on a 19 inch rack, with fan cooling and EMI available in each unit, and supports a RRH and optic CPRI interface.

The following figure shows CDU configuration:

Figure 13. ***CDU Configuration (CDU)***



The following table shows the key features and configurations of each board:

Table 7. ***Key Features and Configuration***

Board	Quantity	Description
UADB	1	Universal platform type A Digital Backplane board assembly • CDU backboard • Routing signals for traffic, control, clocks, power, and so on.
LMD1-J1A	1	Main processing card for clock generation/distribution, network interfacing, IP processing, system OAM function and UDE/UDA function.
LCC4-B1A	Max. 3	Channel processing card for call processing, resource assignment, OFDMA/SC-FDMA channel processing, and CPRI interface with RU.
FANM-C4A	1	Fan Module-C4A CDU cooling fan module

LMD1

The LMD1 provides main processor function, interface with network, interfaces with external devices, and clock generation and distribution.

- Main Processor Feature

The LMD1, LTE main processor of eNB plays role as the highest layer. It is responsible for communication path configuration between UE and EPC, Ethernet Switching functionality for internal eNB, and System OAM. Also, it manages entire hardware and software status within eNB, allocates/manages resources, and collect/report the alarm status information to LSM (LTE System Manager).

- Network Interface Feature

  The LMD1 is Gigabit Ethernet/Fast Ethernet, and it interfaces with EPC.

  Depending on the provided interface, LMD1 can be classified as following types, and operator can choose the interface to use.

  - 100/1000 Base-T Copper (RJ-45) 1 Port
  - 1000 Base-X Small Form factor Pluggable (SFP) 1 Port
  - 1000 Base-X/10 GBase-SR/LR Small Form factor Pluggable+ (SFP+) 1 Port

- External Interface Feature

  The LMD1 can provide Ethernet interface for User Defined Ethernet (UDE) within CDU. Through Fast Ethernet interface of CDU, LMD1 can provide paths to external alarm information (such as Rectifier alarm/control, battery monitoring data or UDE/UDA). Then, this alarm information is sent to LSM.

- Clock Generation and Distribution

  The LMD1's clock module generates 10 MHz, Even, and SFN (System Frame Number) based on the sync signal which is received from GPS, and distributes this to the Hardware block of the system. This clock maintains the internal synchronization of eNB, and used for system operation. Clock module can forward ‘time data’ and ‘location data’ via TOD Path.

  If GPS signal was not received for some reason, clock module provides holdover feature that can maintain the normal clock for specified time period.

LCC4-B1A

The functions of LCC4 are as follows:

- Subscriber channel processing

  The LCC4 modulate the packet data, which is received from LMD1 and transmits it through CPRI to RRH. Reversely, it demodulates the data received from RRH and converts it to the format defined in LTE physical layer standard and transmits it to LMD1.

- CPRI interface

  The LCC4 interfaces with RRH through CPRI. As LCC4 contains a built-in Electrical to Optic (E/O) conversion device and an Optic to Electrical (O/E) conversion device, it can transmit and receive ‘Digital I/Q and C & M’ signals between remote RRHs. The LCC4 can also run loopback tests to check whether the interface between LCC4 and RRHs is in good condition for proper communication. If necessary, the operator can run loopback tests using LSM command.

- 10GE interface

  The LCC4 provides a 10GE interface to support UL CoMP between DUs.

FANM-C4A

The FANM-C4A is the system's cooling fan used to maintain the internal CDU shelf temperature. With this fan, the system can operate normally when the outside temperature of CDU shelf changes.

RRH (LTE FDD, 700 MHz)

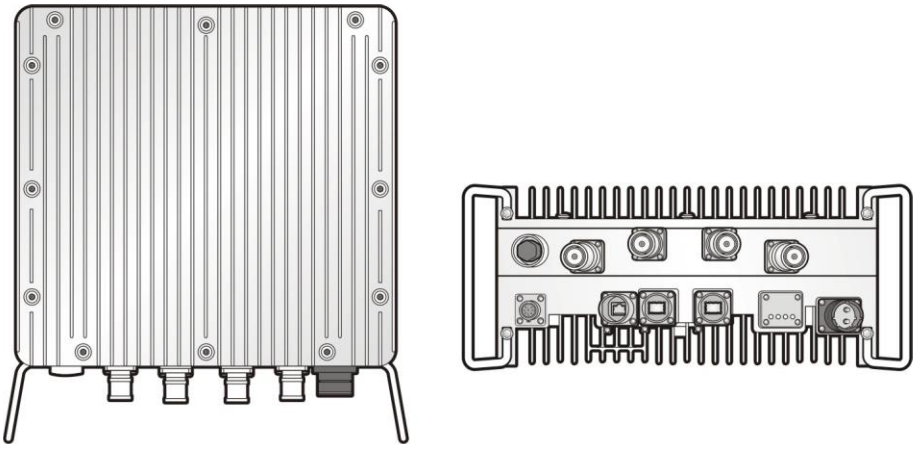
The RRH is installed outdoor by default with a natural cooling convection system.

The RRH, having 4Tx/4Rx, 2Tx/4Rx or 2Tx/2Rx RF chains, is an integrated RF module consisting of a transceiver, a power amplifier, and a filter in an outdoor enclosure.

The major functions of the RRH are as follows:

- 700 MHz (DL: 746 to 756MHz, UL: 777 to 787MHz)
- Supports 10 MHz 4Tx/4Rx, 2Tx/4Rx or 2Tx/2Rx per RRH
- Supports 10 MHz 1 carrier/1 sector
- In case of 4T, 40 W per path (Total 160 W), Max 160 W per carrier
- In case of 2T, 60 W per path (Total 120 W), Max 120 W per carrier
- Up/Down RF conversion
- Performs LNA function
- Amplifies the RF signal level
- Suppresses spurious waves from the bandwidth
- Includes E/O and O/E conversion module for the optical communication with CDU
- Supports Remote Electrical Tilting (RET)

Figure 14. RRH Configuration (RFD01P-13A)



In downlink path, RRH performs O/E conversion for the baseband signals, which is received from CDU via the optic CPRI. The converted O/E signals are converted again into analog signals by the DAC.

The frequency of those analog signals is converted upward through the modulator and those signals are amplified into high-power RF signals through the power amplifier.

The amplified signals are transmitted to antenna through the filter part.

In uplink path, RF signals received through the filter of RRH are low-noise amplified in the Low Noise Amplifier (LNA) and their frequency is then down-converted through the demodulator. These down-converted frequency signals are converted to baseband signals through the ADC. The signals converted into baseband are changed to E/O through CPRI and transmitted to CDU.

The control signals of the RRH are transmitted through the control path in the CPRI.

To save energy, RRH provides the function to turn ON or OFF the power amplifier output through to the software command set according to traffic changes.

When adjusting the maximum output after the initial system installation, RRH adjusts the voltage applied to the main transistor through the software command set in high/low mode to optimize efficiency of the system.

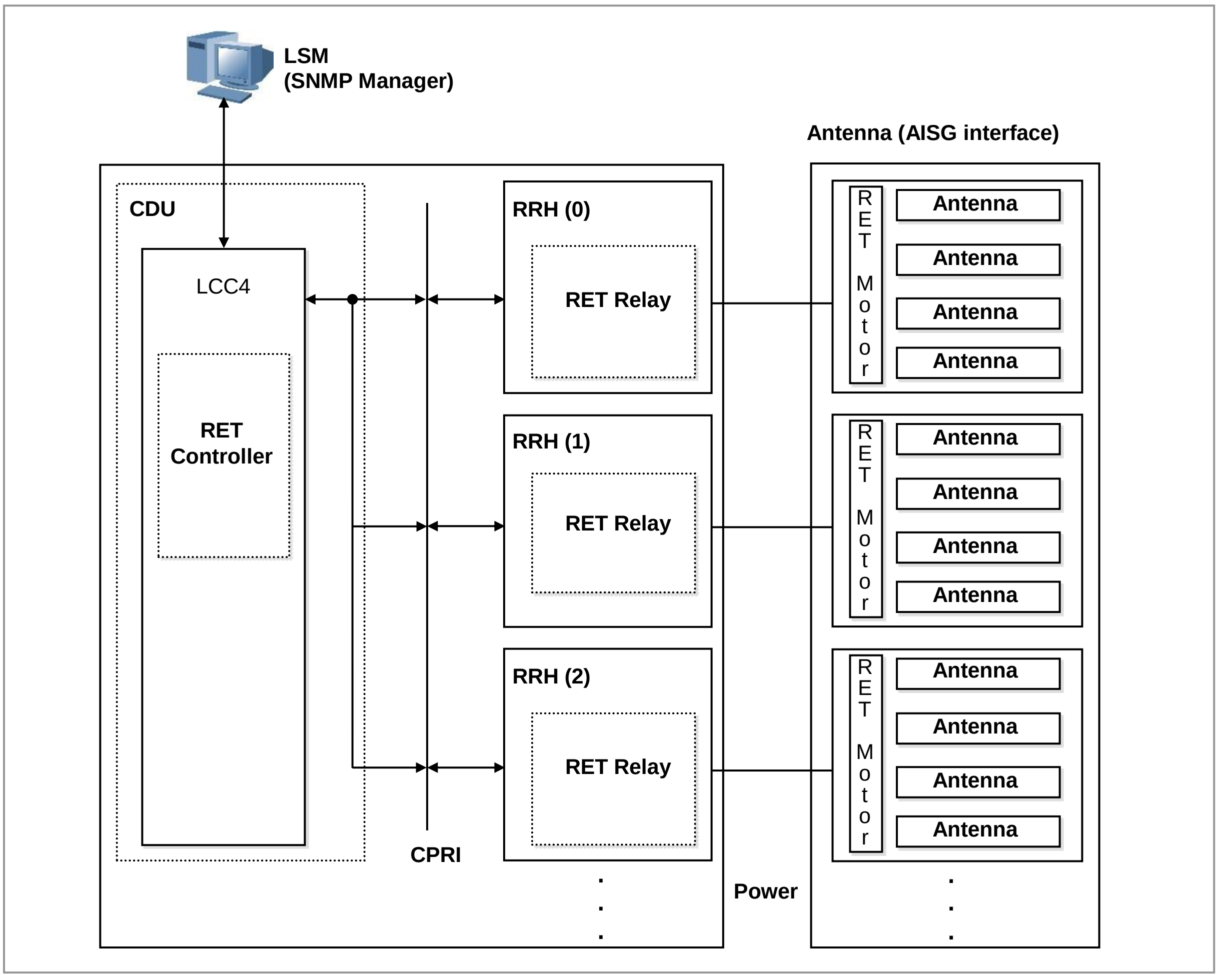
RET

The eNB can support RET function through connection to antenna and RRH, which satisfies the AISG 2.2 interface.

To provide RET function, eNB transmits/receives the control messages to/from LSM through the RET controller within LCC4 and CPRI path of CPRI FPGA.

By using this path, LSM can carry out RET function that controls the antenna tilting angle remotely. In addition, for RET operation, RRH provides power to every connected antenna.

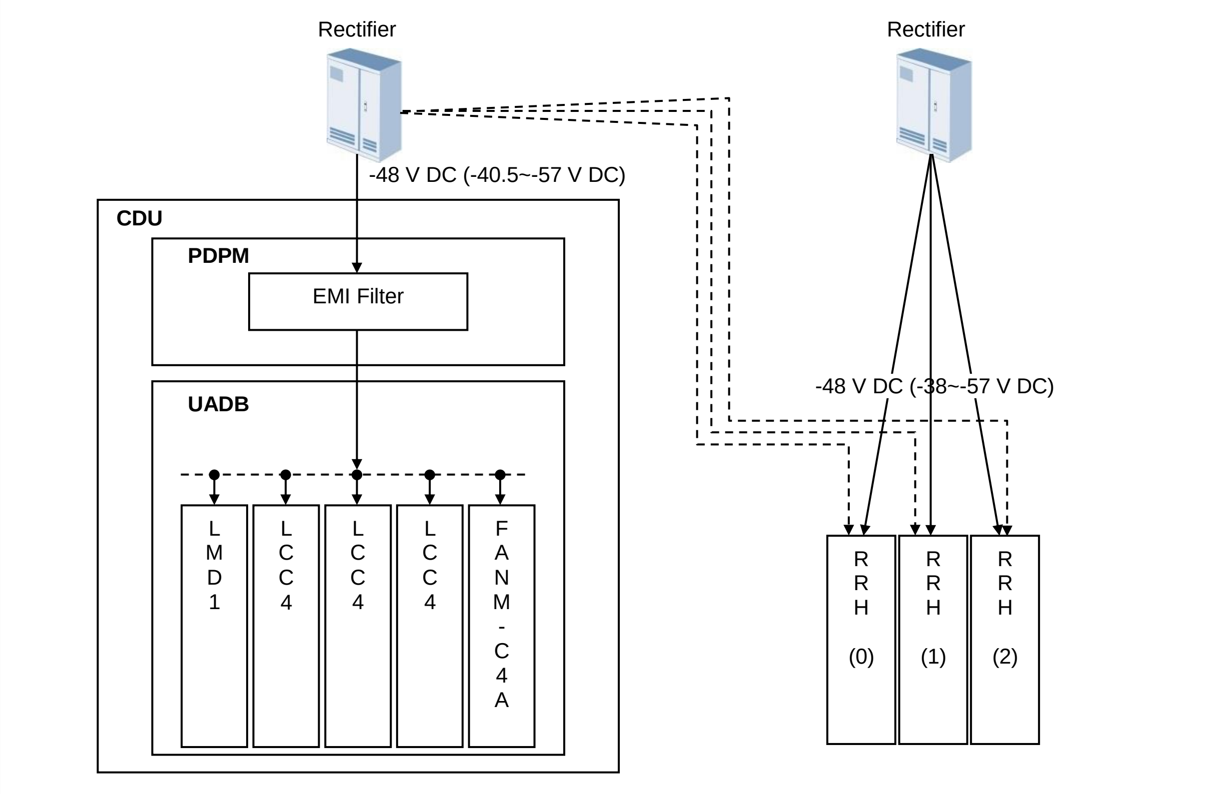
Figure 15. *RET Interface*



Power Supply

The following figure shows the type of power supply to eNB and connection points:

Figure 16. Power Supply Configuration



The power for LMD1 and LCC4-B1As in CDU is supplied through the Power Distribution Panel Module (PDPM) and UADB, a backboard. Each board uses the power by converting -48 V DC provided into the power needed for each part on the board.

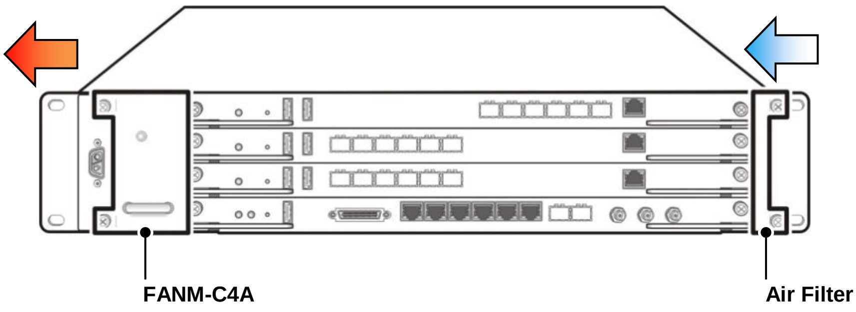
Cooling Structure

CDU

The CDU maintains inside temperature of the shelf at an appropriate range using a system cooling fans (FANM-C4), with this fan, the system can operate normally when the outside temperature of CDU shelf changes.

The following figure shows the heat radiation structure of CDU:

Figure 17. Cooling Structure of CDU



RRH

The RRH is designed to discharge heat effectively through natural convection cooling without an additional cooling device.

External Interface

External Interfaces of LMD1

The following shows the interfaces of LMD1.

Figure 18. LMD1 External Interface

Table 8. LMD1 Unit Description

SILK	Description	Quantity	Connector Type
BH0	BH 1G Copper	1 port	RJ-45
BH1	BH 1G Optic	1 port	SFP
BH2	BH 1G/10G Optic	1 port	SFP+
UDA	User Defined Alarm	1 port	CHAMP-68P
ALM	External Equipment Alarm	1 port	RJ-45
DBG	Debugger RS-232	1 port	USB
ETH	UDE 1G Copper	1 port	RJ-45
LMT	Local Maintenance Terminal	1 port	RJ-45
GNSS	GPS L1 interface	1 port	SMA (Female)
CLK0	Digital clock	1 port	Har link-10P
CLK1	Digital clock	1 port	Har link-10P
STS	CPU Status LED	1	LED PIPE
CLK	Clock Status LED	1	LED PIPE
BH1	BH1 Status LED	1	LED PIPE

SILK	Description	Quantity	Connector Type
BH2	BH2 Status LED	1	LED PIPE

External Interfaces of LCC4

The following shows the interfaces of LCC4.

Figure 19. LCC4 External Interface

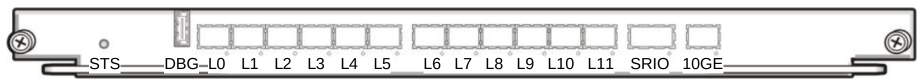


Table 9. LCC4 Unit Description

SILK	Description	Quantity	Connector type
DBG	CPU Debug port RS-232	1 port	USB
L0~L11	CPRI Interface port between DU and RU • SMF CPRI 2.5/5/10 Gbps	12 port	SFP+ LC
SRIO	4 × 10 Gbps	1 port	QSFP+ MPO (Multiple-Fiber Push-On/Pull-Off)
10GE	10 Gb Ethernet	1 port	SFP+
STS	CPU Status LED	1	LED PIPE
L0~L11	CPRI LED	12	LED PIPE
SRIO	SRIO LED	1	LED PIPE

RRH External Interface (LTE FDD)

The following figure shows the external interfaces of LTE FDD RRH:

Figure 20. RFD01P-13A External Interface

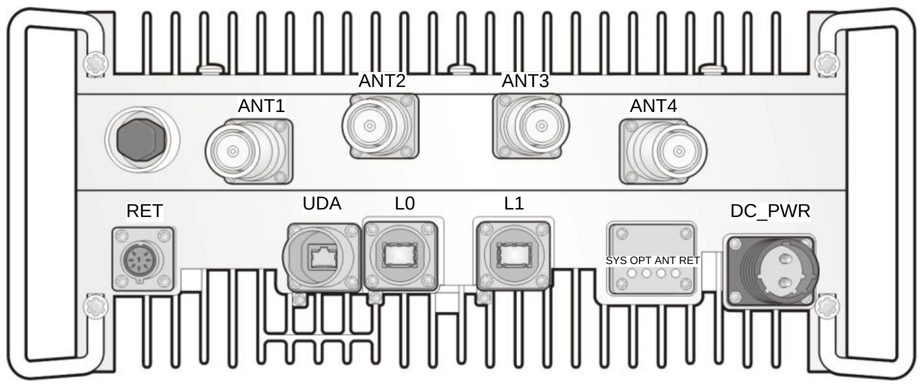


Table 10. RRH External Interface (RFD01P-13A)

I/O Name	Interface	Connector Type	Comments
Antenna Port	RF [OFDMA/SC-FDMA]	4.3-10 (Plus) female x 4	-
DU/RU interface	Optic [CPRI 4.2] defaults speeds 9.8Gbps	SFP (inner) Push-pull type (outer)	Duplex, single mode, 2 ports, 20km
RET	AISG 2.2	IEC 60130-9 Ed 3.0 Circular 8 pin	-
TMA	AISG 2.2	-	TMA is connected through RF ports by bias-T.
UDA	Open/Close (4 alarms)	RJ45 (inner) Push-pull type (outer)	-
DC power	-48V DC	40A 2 pin Push-pull type	-
LED	Status LED	-	SYS, OPT, ANT, RET

Software Structure

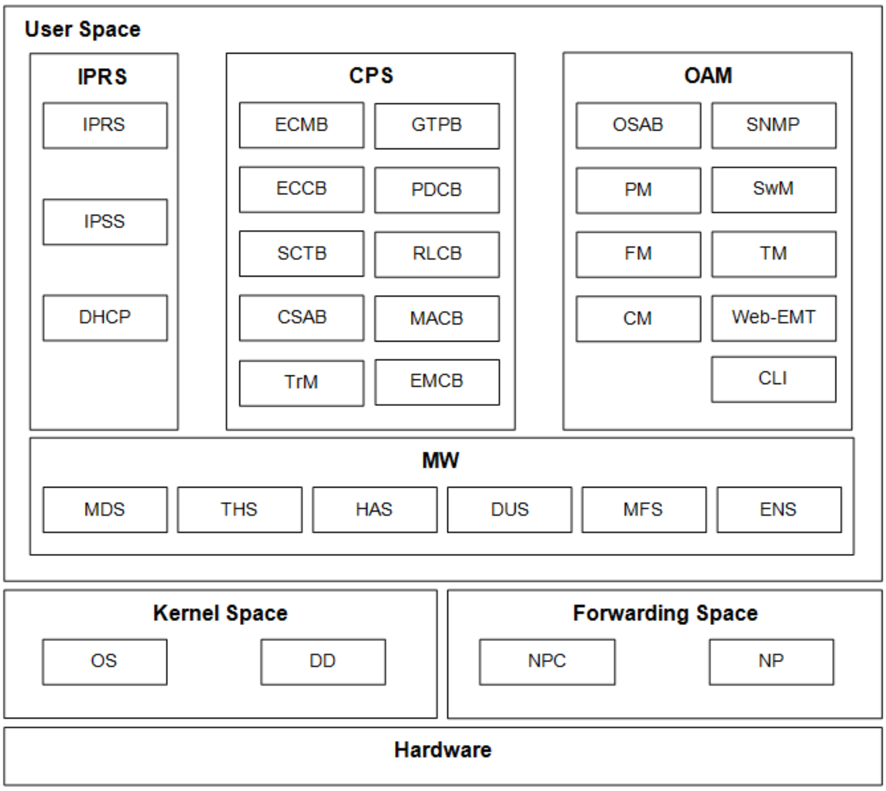
Basic Software Structure

The software of eNB is divided into three parts:

- Kernel Space (OS/DD)
- Forwarding Space (NPC, NP)
- User Space (MW, IPRS, CPS, OAM)

The following figure shows eNB software structure:

Figure 21. eNB Software Structure



Operating System (OS)

The OS initializes and controls the hardware devices and ensures that software is ready to run on the hardware devices.

The OS consists of a booter, kernel, root file system (RFS), and utility.

- Booter: Performs initialization on boards. It initializes the CPU, L1/L2 Cache, UART, and MAC and the devices such as CPLD and RAM within each board, and runs the u-boot.

- Kernel Manages the operation of multiple software processes and provides various primitives to optimize the use of limited resources.
- RFS: Stores and manages the binary files, libraries, and configuration files necessary for running and operating the software by File-system Hierarchy Standard 2.2 (FHS).
- Utility: Provides the functions for managing the complex programmable logic device (CPLD), LED, watchdog, and environment and inventory information, measuring and viewing the CPU load, and storing and managing fault information when a processor goes down.

Device Driver (DD)

The DD allows applications to operate normally on devices that are not directly controlled from OS in the system. The DD consists of physical DD and virtual DD.

- Physical DD: Provides the interface through which an upper application can configure, control, and monitor the external devices of the processor. (Switch device driver and Ethernet MAC driver, and so on.)
- Virtual DD: In case of physical network interfaces, virtual interfaces are created on the kernel so that the upper applications may control the virtual interfaces instead of controlling the physical network interfaces directly.

Network Processing Control (NPC)

The NPC, via the interfaces with the upper processes such as IPRS and OAM, constructs and manages various tables necessary for processing packets of the NP software described above, and performs the network statistics collection function and the network status management function.

Network Processing (NP)

The NP is the software which processes the packets required for backhaul interface.

The functions of the NP are as follows:

- Packet RX and TX
- IPv4 and IPv6
- Packet RX and TX
- IPv4 and IPv6
- Packet queuing and scheduling
- MAC filtering
- IP Packet forwarding
- IP fragmentation and reassembly
- Link aggregation
- VLAN termination

- Access Control List (ACL)
- MAC filtering
- IP Packet forwarding
- IP fragmentation and reassembly
- Link aggregation
- VLAN termination
- ACL (Access Control List)

Middleware (MW)

The MW ensures seamless communication between OS and applications on various hardware environments. It provides a Message Delivery Service (MDS) between applications, Debugging Utility Service (DUS), Event Notification Service (ENS), High Availability Service (HAS) for redundancy management and data backup, Task Handling Service (THS), and Miscellaneous Function Service (MFS).

- MDS: Provides all services related to message transmitting and receiving.
- DUS: Provides the function for transmitting debugging information and command between applications and operator.
- ENS: Adds and manages various events such as timers, and provides the function for transmitting an event message to destination at the time when it is needed.
- HAS: Provides the data synchronization function and the redundancy state management function.
- THS: Provides the task creation/termination function, task control function, and function for providing task information, and so on.
- MFS: The MFL is responsible for all hardware-dependent functions, such as accessing physical addresses of hardware devices.

IP Routing Software (IPRS)

The IPRS is the software that provides IP routing and IP security function for eNB backhaul. The IPRS is configured with IPRS, IP Security Software (IPSS) and Dynamic Host Configuration Protocol (DHCP), and each of them provide the functions as follows.

- IPRS: Collects and manages the system configuration and status information necessary for IP routing. Based on this data, IPRS provides the function for creating routing information.
  - Managing Ethernet, VLAN-TE, and link aggregation
  - IP addresses management
  - IP routing information management
  - QoS management

- IPSS: Software that performs the security functions for the IP layer. It is responsible for filtering based on the IP address, TCP/UDP port number, and protocol type.
- DHCP: Software block that performs the automatic IP address allocation function. It is responsible for obtaining an IP address automatically by communicating with DHCP server.

In the following sections, the Master OAM Board and Call Processing Board, where the software runs on, indicate LMD1 and RFD01P-13A of CDU each.

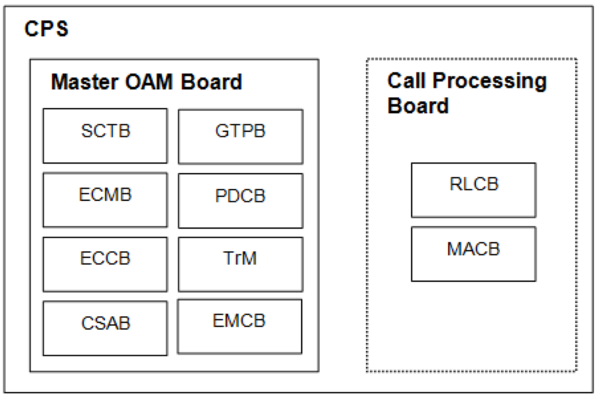
CPS Block

The Call Processing Software (CPS) block performs resource management of LTE eNB and call processing function in eNB, which is defined in the 3GPP. Also, CPS performs the interface function with EPC, UE, and neighbor eNBs. The CPS consists of eNB control processing subsystem (ECS), which is responsible for network access and call control functions, and eNB data processing subsystem (EDS), which is responsible for user traffic handling.

In addition, depending on eNB functions defined in 3GPP, ECS consists of SCTB, ECMB, ECCB, SCTB, CSAB, TrM, and EMCB. Also, EDS consists of GTPB, PDCB, RLCB, and MACB.

The following figure shows the CPS structure:

Figure 22. CPS Structure



Stream Control Transmission protocol Block (SCTB)

The SCTB is responsible for establishing S1 interface between eNB and MME, and establishes X2 interface between neighbor eNBs. It operates on the master OAM board.

The major functions of SCTB are as follows:

- S1 interfacing

- X2 interfacing

eNB Common Management Block (ECMB)

The ECMB performs call processing function such as the system information transmission and eNB overload control for each eNB and cell. It operates on the master OAM board.

The major functions of ECMB are as follows:

- Setting/Releasing cell
- Transmitting system information
- eNB overload control
- Access barring control
- Resource measurement control
- Transmission of cell load information

eNB Call Control Block (ECCB)

The ECCB performs the function to control the call procedure until exit after call setup and call processing function for MME and neighbor eNBs. It operates on the master OAM board.

The major functions of ECCB are as follows:

- Radio resource management
- Idle to Active status transition
- Setting/changing/releasing bearer
- Paging Functions
- MME selection/load balancing
- Call admission control
- Security function
- Handover control
- UE measurement control
- Statistics processing
- Call processing function related to the SON (Mobility Robustness, RACH optimization)

eNB MBMS Control Block (EMCB)

The EMCB performs the function to control call procedure related to eMBMS and process call with MME or neighbour eNB.

The major functions of EMCB are as follows:

- M3AP function
- SFN SYNC function
- EMCB statistics processing
- MCE troubleshooting

CPS SON Agent Block (CSAB)

The CSAB supports the SON function, which is performed in eNB CPS. It operates on the master OAM bard.

The major functions of CSAB are as follows:

- Mobility robustness optimization
- RACH optimization
- Mobility load balancing

GPRS Tunneling Protocol Block (GTPB)

The GTPB is the user plane call processing function of eNB. It processes the GTP.

It operates on the master OAM board.

The major functions of GTPB are as follows:

- GTP tunnel control
- GTP management
- GTP data transmission
- SYNC protocol

Trace Management (TrM)

The TrM updates the trace data and Call Summary Log (CSL), which are received from each software entity (PDCP, MAC and RLC). The updated data is periodically transmitted to LSM. It operates on the master OAM board.

The major functions of TrM are as follows:

- Signaling based trace
- Cell traffic trace
- CSL function
- Trace data transmission to the Trace Collection Entity (TCE) address

PDCP Block (PDCB)

The PDCB is the user plane call processing function of eNB. It processes the PDCP.

It operates on the master OAM board.

The major functions of PDCB are as follows:

- Header compression or decompression (ROHC only)
- Transmitting user data and control plane data
- PDCP sequence number maintenance
- DL/UL data forwarding at handover
- Ciphering and deciphering for user data and control data
- Control data integrity protection
- Timer-based PDCP SDU discarding

Radio Link Control Block (RLCB)

The RLCB is the user plane call processing function of eNB. It processes the RLC protocol. It operates on the call processing board.

The major functions of RLCB are as follows:

- Transmission for the upper layer PDU
- ARQ function used for the AM mode data transmission
- RLC SDU concatenation, segmentation and reassembly
- Re-segmentation of RLC data PDUs
- In sequence delivery
- Duplicate detection
- RLC SDU discard
- RLC re-establishment
- Protocol error detection and recovery

Medium Access Control Block (MACB)

The MACB is the user plane call processing function of eNB. It processes the MAC protocol. It operates on the call processing board.

The major functions of MACB are as follows:

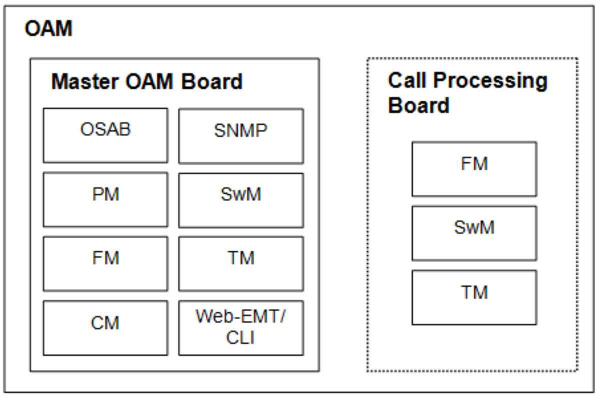
- Mapping between the logical channel and the transport channel
- Multiplexing & de-multiplexing
- HARQ
- Transport format selection
- Priority handling between UEs
- Priority handling between logical channels of one UE

OAM Blocks

The Operation And Maintenance (OAM) is responsible for operation and maintenance in eNB.

The OAM is configured with OSAB, PM, FM, CM, SNMP, SwM, TM, Web-EMT, and CLI.

Figure 23. OAM Structure



The major functions of OAM are as follows:

OAM SON Agent Block (OSAB)

To allow the operator of a management system to perform LTE SON function of eNB, the OSAB supports the automatic configuration & installation of system information, and automatic creation & optimization of a neighbor list. The OSAB operates on the master OAM board.

The main functions of OSAB are as follows:

- System information, automatic configuration, and automatic installation
- Optimizing automatic neighbor relation

Performance Management (PM)

The PM collects and provides performance data so that the operator of the management system can determine the performance of LTE eNB. The PM collects events and performance data during system operation and transmits them to the management systems. Overall statistics files are generated in binary form every 15 minutes, and these files are collected in the management system via FTP/SFTP on the regular basis.

The main functions of PM are as follows:

- Collecting statistics data
- Storing statistics data
- Transmitting statistics data

Fault Management (FM)

The FM performs fault and status management functions on eNB's hardware and software. It applies filtering to a detected fault, notifies the management system, and reflects the fault severity and threshold changes in the fault management. Also, it operates on the master OAM board and call processing board.

The main functions of FM are as follows:

- Detecting faults and reporting alarms
- Viewing alarms
- Alarm filtering
- Setting alarm severity
- Setting alarm threshold
- Alarm correlation
- Status management and reporting
- Status retrieval

Configuration Management (CM)

The CM manages eNB configuration and parameters in PLD format and provides the data that the software blocks need. Through the command received from SNMP/CLI/Web-EMT, CM provides the functions that can grow/degrow system configuration, and display/change the configuration data and operation parameters. The CM operates on the master OAM board.

The main functions of CM are as follows:

- Grow/degrow of system and cell
- Retrieval, change, grow & degrow of configuration information
- Retrieval & change of the call parameters
- Retrieval, addition, deletion, and change of neighbors

Simple Network Management Protocol (SNMP)

The SNMP is an SNMP agent for supporting a standard SNMP (SNMPv2c/SNMPv3).

It performs interfacing with upper management systems and interoperates with the internal subagents. When receiving a request for a standard MIB object from LSM, the SNMP processes the request independently. When receiving a request for a private MIB object, it transmits the request to the corresponding internal subagent. The SNMP operates on the master OAM board.

The main functions of SNMP are as follows:

- Processing the standard MIB

  When receiving a request for MIB-II object, the SNMP processes it independently and transmits a response.

- Processing a private MIB

  When receiving a request for a private MIB object, the SNMP does not process it independently; it transmits the request to the corresponding internal subagent. Then, SNMPD receives a response from the subagent and transmits it to the manager.

Soft Ware Management (SwM)

The SwM downloads and runs the package for each board under the file list downloaded during the preloading procedure. The SwM monitors the software that has been run, provides information on the running software, and supports software restart and upgrade according to the command. The SwM operates on the master OAM board and call processing board.

The main functions of SwM are as follows:

- Downloading and installing software and data files
- Reset of hardware unit and system
- Status monitoring of the software unit in operation
- Managing and updating the software and firmware information
- Software upgrade
- Inventory Management Functions

Test Management (TM)

The TM checks internal and external connection paths of system or the validity of its resources. The connection paths are classified into system internal IPC path and external path to other NEs.

Moreover, TM conducts on-demand tests upon operator’s request and periodic tests according to the schedule set by the operator. The TM operates on the master OAM board and call processing board.

The main functions of TM are as follows:

- Enable/disable the Orthogonal Channel Noise Simulator (OCNS)
- Setting/clearing a Model
- Ping test
- Measuring the Tx/Rx power
- Measuring the antenna Voltage Standing Wave Ratio (VSWR)

Web-based Element Maintenance Terminal (Web-EMT)

The Web-EMT is a block used to interface with web client of the console terminal that uses a web browser. It operates as a web server. The Web-EMT support highly secured Secure Sockets Layer (SSL) based HTTP communication. The

Web-EMT operates on the master OAM board.

The main functions of Web-EMT are as follows:

- Web server function
- Interoperating with other OAM blocks for processing command

Command Line Interface (CLI)

The CLI is a block to interface with a target CLI when it is connected to a console terminal in the SSH method. The CLI software block processes CLI command and shows the result. The CLI operates on the master OAM board.

The main functions of CLI are as follows:

- CLI user management
- Command input and result output
- Fault/Status message output

Chapter 4 Message Flow

Data Traffic Flow

Sending Path

The user data received from EPC passes through the network interface module and is transmitted through Ethernet switch to CDU. The transmitted user data goes through baseband-level digital processing before being configured for CPRI, and then E/O converted. The converted signal is transmitted through the optic cable to the remote RRH. The RRH performs O/E conversion for a received optic signal. The converted baseband signal from the wideband is converted into an analog signal and transmitted through the high-power amplifier, filter, and antenna.

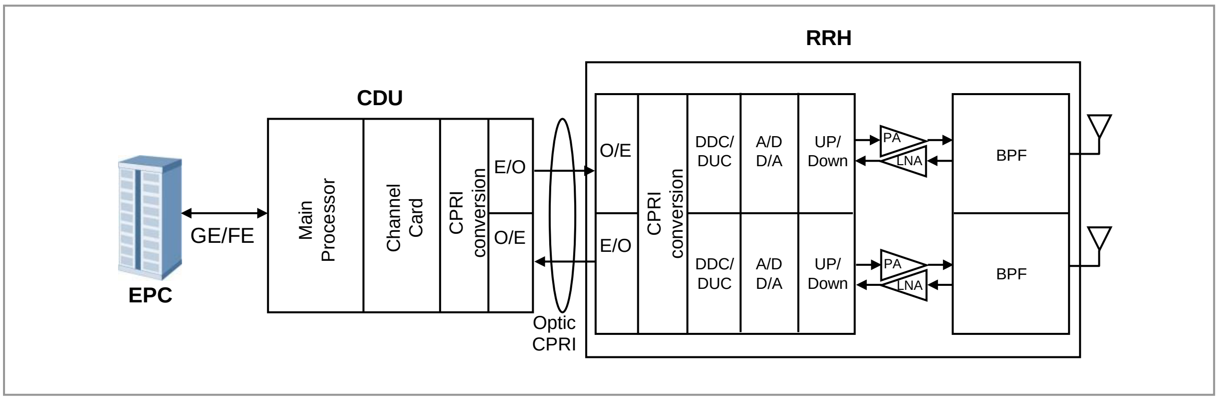
Receiving Path

The RF signal received by the antenna goes through RRH filter and low-noise amplification by the LNA.

The RF down-conversion and digital conversion are performed for this signal, and the signal is then converted to a baseband signal. It is configured for CPRI, and goes through the E-O conversion again.

The converted signal is transmitted through optic cable to the CDU. The data for which the SC-FDMA signal processing is carried out in the CDU is converted to the Gigabit Ethernet frame and transmitted from the CDU to EPC via the GE/FE.

***Figure 24.* Data Traffic Flow**



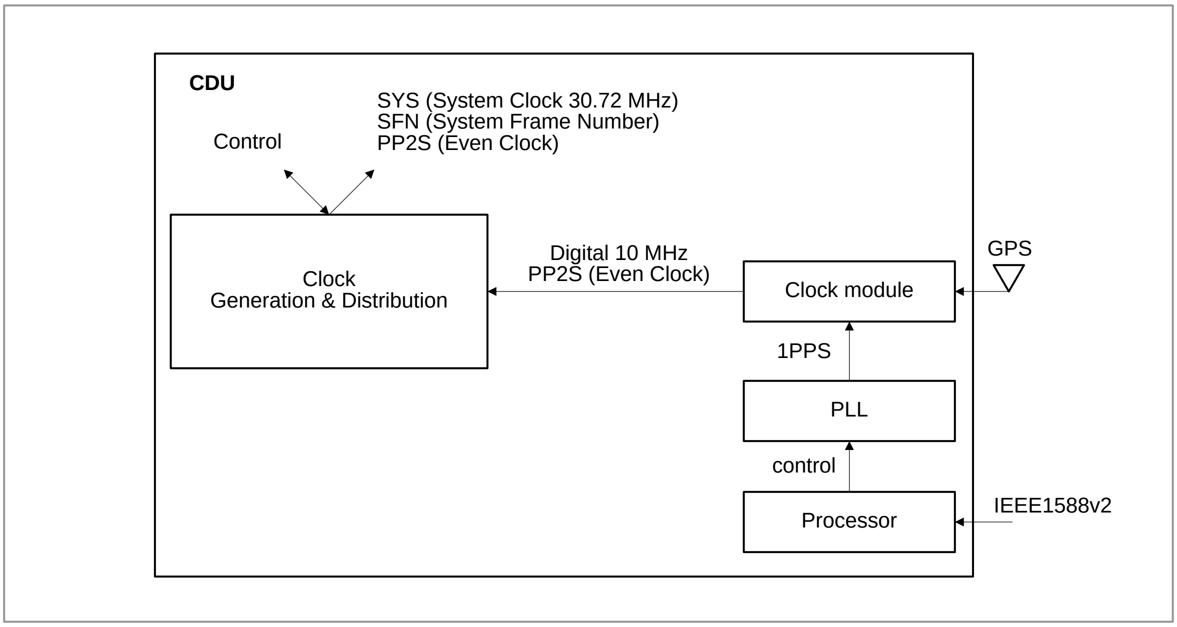
Network Sync Flow

The eNB uses GPS and IEEE1588v2 for synchronization. Clock module receives synchronization signal from the GPS, creates and distributes clocks. For IEEE1588v2, a processor receives IEEE1588v2 packet from backhaul, and generate clock through PLL and clock module.

Supported PTP profiles are as below:

- IEEE1588v2 unicast negotiation mode (phase)
- IEEE1588v2 unicast negotiation mode (frequency)
- ITU-T G.8265.1 (frequency)
- ITU-T G.8275.1 (phase)
- ITU-T G.8275.2

Figure 25. Network Synchronization Flow



Alarm Signal Flow

An environmental fault or hardware mount/dismount is reported with an alarm signal, which is collected by LMD1 of the CDU, and reported to LTE System Manager (LSM). The operator can also provide custom alarms through the UDA.

The following alarms are collected by the LMD1 of CDU:

Table 11. Alarms

Alarm Type	Description	Applicable

Alarm Type	Description	Applicable
Function Fail Alarm	Fault alarm due to software/hardware problems defined as 'Function Fail'	LCC4-B1A
Power Fail Alarm	Fault alarm due to power problems	LCC4-B1A
Deletion Alarm	System report alarm due to hardware mount/dismount	LCC4-B1A
UDA	Alarm that the operator wants to provide	LMD1-J1A
RF Unit Alarm	RF unit alarm	RRH

Reset command is executed via LSM and transmitted to LMD1. Then, LMD1 reset itself, lower boards or unit.

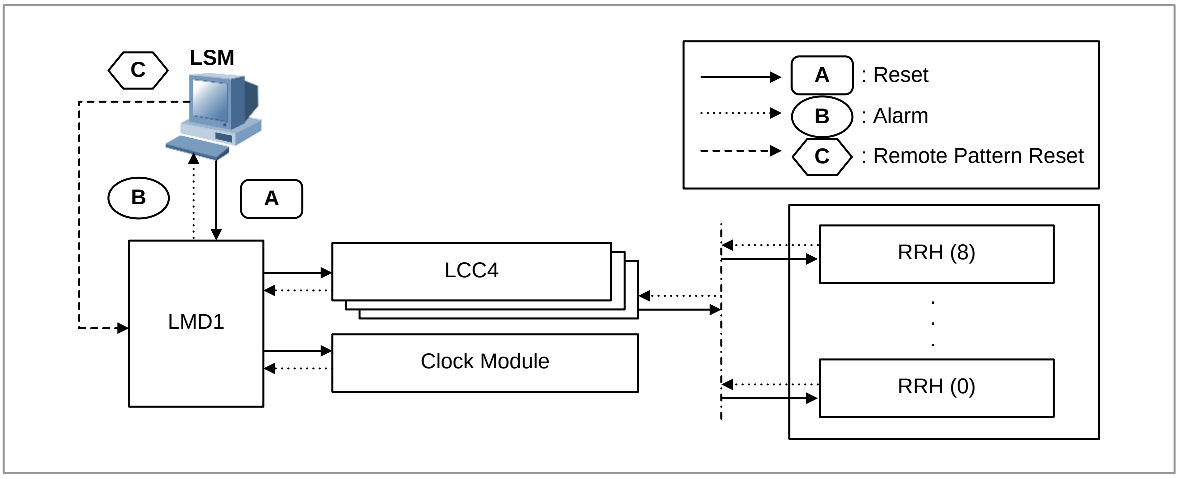
The function and types of the reset are as follows:

***Table 12.* Reset Commands**

Alarm Type	Description	Applicable
HW Reset	Reset the board or unit by cutting off the power quickly	LMD1-J1A, RRH
SW Reset	Reset the OS of the LMD1	LMD1-J1A

Figure below depicts alarm flow for LMD1.

***Figure 26.* Alarm Flow**



Loading Flow

The processors and devices of the system can be downloaded through Loading procedure from LSM software executables, data, and other elements, which are required to perform their functions.

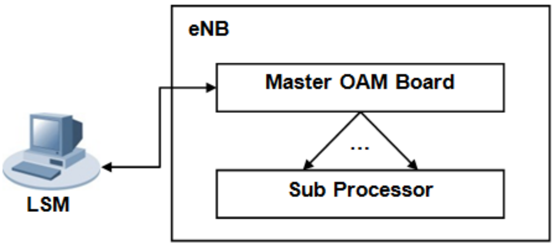
During the system initialization procedure, Loading the system is performed. Loading is also involved when a specific board is mounted in the system, when a hardware reset is carried out, or when the operator of an upper management system restarts a specific board.

At the first system initialization, the system is loaded through LSM. As the loading information is stored in the internal storage, no unnecessary loading is carried out afterward. After the first system initialization, it compares software files and versions of LSM and downloads the changed software files.

The loading information contains the software image and default configuration information file, and so on.

The following figure shows the Loading signal flow:

Figure 27. Loading Signal Flow



Operation and Maintenance Message Flow

The operator can check and change status of eNB through the management system.

To accomplish this, eNB provides the SNMP agent function, and LSM operator can carry out the operation and maintenance functions of eNB remotely through the SNMP.

Moreover, operator can carry out maintenance function based on Web-EMT in the console terminal using web browser. After connecting to telnet or SSH, maintenance function can be carried out through the CLI.

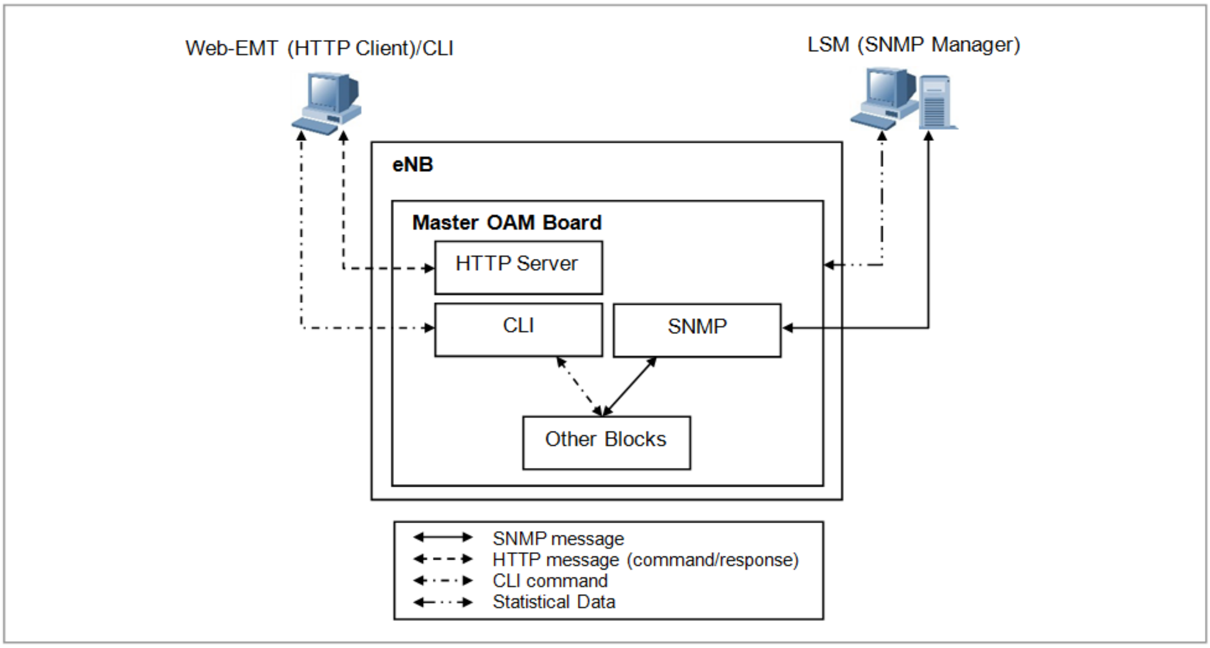
The statistical information provided by eNB is given to operator by collection interval.

The operation and maintenance in eNB is performed using the SNMP message between SNMP agent in the main OAM and the SNMP manager of the LSM.

The eNB processes various operation and maintenance messages received from the SNMP manager of the management systems. Once processed, eNB transmits their results to the SNMP manager, and reports the events such as faults and status changes to the SNMP manager in real-time.

The following figure shows the operation and maintenance signal flow.

Figure 28. ***Operation and Maintenance Signal Flow***

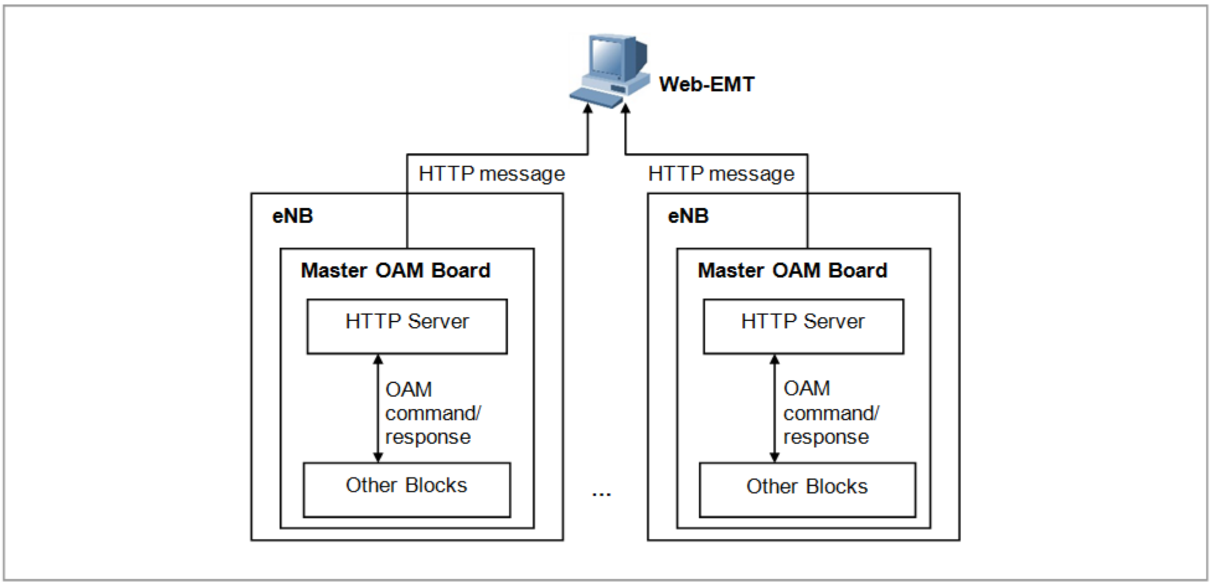


Web-EMT

The Web-EMT is a GUI-based console terminal. It is a tool that monitors the status of devices and performs operation and maintenance tasks by connecting directly to eNB. The operator can run the Web-EMT using Internet Explorer, without installing separate software. The GUI is provided using the HTTPs protocol internally.

The following figure shows the Web-EMT interface:

Figure 29. Web-EMT Interface



Through Web-EMT, the operator can reset or restart eNB or its internal boards, view and change the configuration and operation parameter values, monitor the system status and faults, carry out diagnostic functions, and so on. But the resource grow and degrow functions and changing the operation information related to neighbor list are available from LSM only, which manages the entire networks and the loading images.

CLI

The CLI is the method used for operation or maintenance of eNB. The operator can perform the text-based operation and maintenance via CLI after login to eNB via telnet in PC.

The functions of the CLI are as follows:

Loading

The CLI can reset or restart board of eNB.

Configuration Management

The CLI provides the function that executes Man-to-Machine Command (MMC) that allows viewing and changing the configuration information for eNB.

Status Management

The CLI provides the function that manages status for the processors and various devices of eNB.

Fault Management

The CLI checks whether there are any faults with the processors and various devices of eNB. Also, it provides the operator with the location and each fault logs. Since CLI can display both of the hardware and software faults, the operator can know all faults that occur in eNB.

Diagnosis and Test

The CLI provides the function that diagnoses the connection paths, processors, and various devices that are being operated in eNB, and provides the test function that can detect a faulty part. The major test functions that CLI can perform includes, measuring the transmitting output and the antenna diagnosis function, and so on.

Appendix Acronyms

3GPP	3rd Generation Partnership Project
256 QAM	256 Quadrature Amplitude Modulation
AC	Admission Control
ACL	Access Control List
ADC	Analog to Digital Converter
AKA	Authentication and Key Agreement
AISG	Antenna Interface Standards Group
AM	Acknowledged Mode
AMBR	Aggregated Maximum Bit Rate
ANR	Automatic Neighbor Relation
ARQ	Automatic Repeat Request
AS	Access Stratum
BGP	Border Gateway Protocol
BSS	Base Station System
C & M	Control & Management
CC	Chase Combining
CDD	Cyclic Delay Diversity
CDU	Cabinet DU
CLI	Command Line Interface
CM	Configuration Management
CoS	Class of Service
CP	Cyclic Prefix
CPLD	Complex Programmable Logic Device
CPRI	Common Public Radio Interface
CPS	Call Processing Software
CS	Circuit Service
CSAB	CPS SON Agent Block
CSL	Call Summary Log
CSM	Core System Manager
DAC	Digital to Analog Converter
DBMS	Database Management System
DD	Device Driver
DDC	Digital Down Conversion
DFT	Discrete Fourier Transform
DHCP	Dynamic Host Configuration Protocol
DiffServ	Differentiated Services
DL	Downlink
DL-SCH	Downlink Shared Channel
DSCP	Differentiated Services Code Point
DTM	Dual Transfer Mode

DU	Digital Unit
DUC	Digital Up Conversion
DUS	Debugging Utility Service
ECCB	eNB Call Control Block
ECMB	eNB Common Management Block
ECS	eNB Control processing Subsystem
EDS	eNB Data processing Subsystem
eMBMS	enhanced/evolved Multimedia Broadcast Multicast Services
EMC	Electromagnetic Compatibility
EMI	Electromagnetic Interference
EMS	Element Management System
eNB	evolved UTRAN Node B
ENS	Event Notification Service
E/O	Electric-to-Optic
EPC	Evolved Packet Core
EPS	Evolved Packet System
E-UTRAN	Evolved UTRAN
FANM	Fan Module
FE	Fast Ethernet
FHS	File-system Hierarchy Standard 2.2
FM	Fault Management
FPGA	Field Programmable Gate Array
FTP	File Transfer Protocol
GBR	Guaranteed Bit Rate
GE	Gigabit Ethernet
GERAN	GSM EDGE Radio Access Network
GPRS	General Packet Radio Service
GPS	Global Positioning System
GPSR	GPS Receiver
GTP	GPRS Tunnelling Protocol
GTPB	GPRS Tunnelling Protocol Block
GTP-U	GTP-User
GUI	Graphical User Interface
GW	Gateway
HARQ	Hybrid Automatic Repeat Request
HAS	High Availability Service
HO	Handover
HSS	Home Subscriber Server
HTTP	Hypertext Transfer Protocol
HTTPs	Hyper Text Transfer Protocol over SSL
ICIC	Inter-Cell Interference Coordination
IDFT	Inverse Discrete Fourier Transform
IETF	Internet Engineering Task Force

IP	Internet Protocol
IPRS	IP Routing Software
IPSS	IP Security Software
IPv4	Internet Protocol version 4
IPv6	Internet Protocol version 6
IR	Incremental Redundancy
LCC4	LTE Channel card type C2
LMD1	LTE Main card typeD1
LNA	Low Noise Amplifier
LSM	LTE System Manager
LTE	Long Term Evolution
MAC	Media Access Control
MACB	Medium Access Control Block
MBMS GW	Multimedia Broadcast Multicast Service Gateway
MBR	Maximum Bit Rate
MBSFN	MBMS over a Single Frequency Network
MCS	Modulation Coding Scheme
MDS	Message Delivery Service
MFS	Miscellaneous Function Service
MIB	Master Information Block
MIMO	Multiple-Input Multiple-Output
MLB	Mobility Load Balancing
MMC	Man Machine Command
MME	Mobility Management Entity
MSC	Mobile Switching Center
MSS	Master SON Server
MU	Multiuser
MW	Middleware
NAS	Non-Access Stratum
NE	Network Element
NP	Network Processing
NPC	Network Processing Control
NR	Neighbor Relation
NRT	Neighbor Relation Table
OAM	Operation and Maintenance
OCNS	Orthogonal Channel Noise Simulator
OCS	Online Charging System
O/E	Optic-to-Electric
OFCS	Offline Charging System
OFDM	Orthogonal Frequency Division Multiplexing
OFDMA	Orthogonal Frequency Division Multiple Access
OS	Operating System
OSAB	OAM SON Agent Block
OSPF	Open Shortest Path First

OSS	Operating Support System
PAPR	Peak-to-Average Power Ratio
PCEF	Policy and Charging Enforcement Function
PCI	Physical Cell Identity
PCRF	Policy and Charging Rule Function
PDCB	PDCP Block
PDCP	Packet Data Convergence Protocol
PDN	Packet Data Network
PDPM	Power Distribution Panel Module
PDU	Protocol Data Unit
P-GW	PDN Gateway
PLER	Packet Loss Error Rate
PM	Performance Management
PMIP	Proxy Mobile IP
PP2S	Pulse Per 2 Seconds
PRACH	Physical Random Access Channel
PRB	Physical Resource Block
PSS	Primary Synchronization Signal
QCI	QoS Class Identifier
QoS	Quality of Service
QPSK	Quadrature Phase Shift Keying
RACH	Random Access Channel
RB	Radio Bearer
RB	Resource Block
RET	Remote Electrical Tilting
RF	Radio Frequency
RFS	Root File System
RLC	Radio Link Control
RLCB	Radio Link Control Block
RMI	Remote Method Invocation
RO	RACH Optimization
ROHC	Robust Header Compression
RRC	Radio Resource Control
RRH	Remote Radio Heads
RRM	Radio Resource Management
RU	Radio Unit

SAMSUNG

LTE eNB
System Description

Document Version 2.0