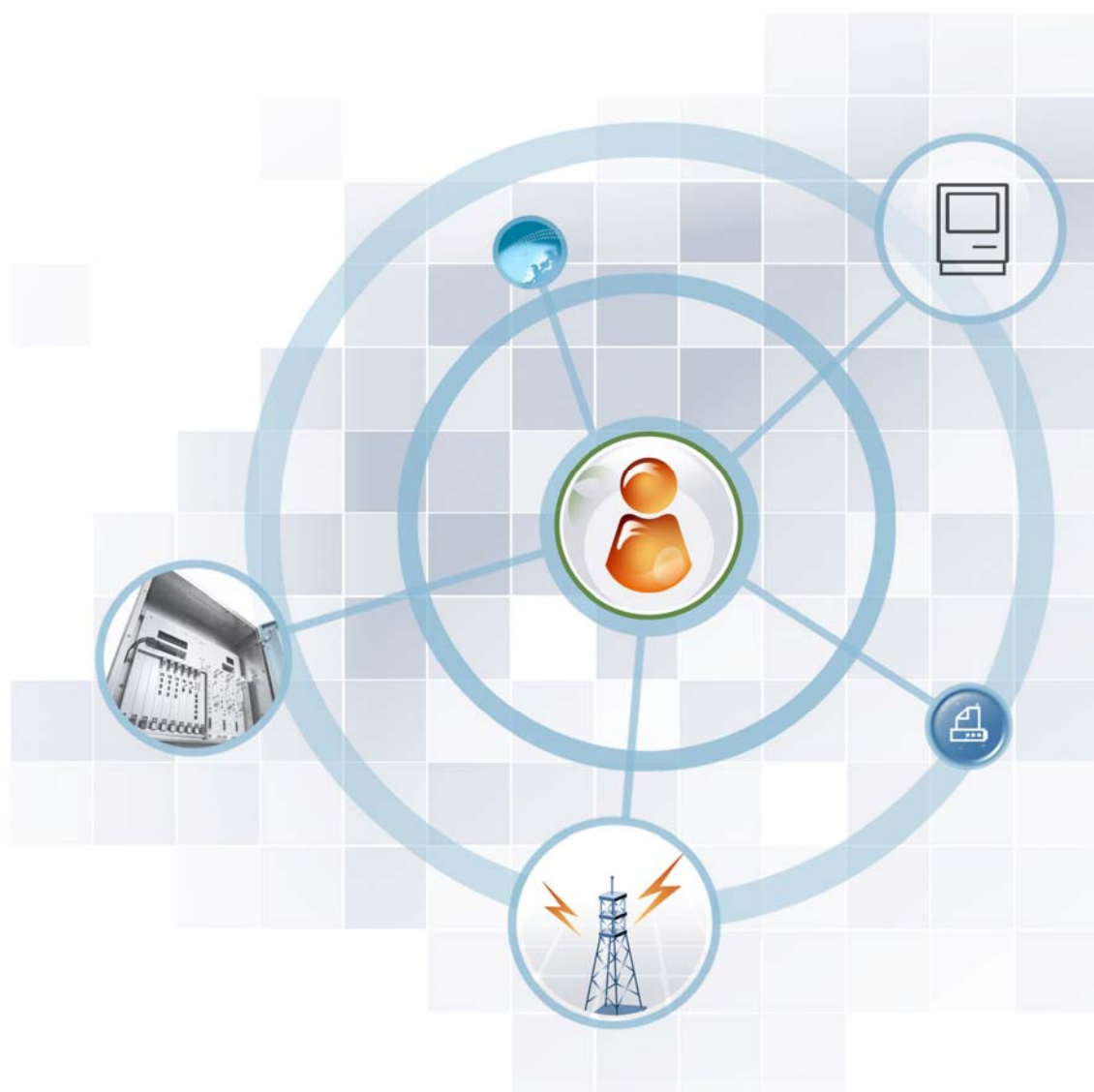


Ver.

LTE eNB

System Description



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INTRODUCTION

Purpose

This manual describes the features, functions and configuration of LTE eNB.

Content and Organization

This manual consists of five Chapters and Abbreviations.

CHAPTER 1. Overview of Samsung LTE System

- Introduction to Samsung LTE System
- Network Configurations of Samsung LTE Network
- Functional Architecture of Samsung LTE

CHAPTER 2. Overview of LTE eNB

- Introduction to LTE eNB
- Key Functions
- Specifications
- System-to-System Interfaces

CHAPTER 3. LTE eNB Architecture

- Hardware Architecture
- Software Architecture

CHAPTER 4. Message Flows

- Call processing Message Flow
- Data Message Flow
- Network Synchronization Flow
- Alarm Signal Flow
- Loading Flow
- Operation/Maintenance Message Flow

CHAPTER 5. Supplementary Functions and Tools

- Web-EMT
- About CLI

ABBREVIATIONS

Provides explanations of the abbreviations used throughout this manual.

Conventions

The following symbols are used in this manual. The following types of paragraphs contain special information that must be carefully read and thoroughly understood.



NOTE

This provides references for additional information.

Revision History

EDITION	DATE OF ISSUE	REMARKS
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TABLE OF CONTENTS

INTRODUCTION	I
Purpose	I
Content and Organization.....	I
Conventions.....	II
Revision History.....	II
CHAPTER 1. Overview of Samsung LTE System	1-1
1.1 Introduction to Samsung LTE System	1-1
1.2 Samsung LTE Network Configuration.....	1-2
1.3 LTE System Functional Architecture.....	1-4
CHAPTER 2. Overview of LTE eNB	2-1
2.1 Introduction to LTE eNB.....	2-1
2.2 Key Functions	2-7
2.2.1 Physical layer processing	2-7
2.2.2 Call Processing.....	2-10
2.2.3 IP Processing.....	2-12
2.2.4 SON.....	2-13
2.2.5 Convenient Operation and Maintenance	2-14
2.3 Specifications	2-16
2.4 System-to-System Interface.....	2-18
2.4.1 Interface Architecture	2-18
2.4.2 Protocol Stack.....	2-19
CHAPTER 3. LTE eNB Architecture	3-1
3.1 Hardware Architecture	3-1
3.1.1 UADU	3-4
3.1.2 L8HU	3-6
3.1.3 Power supply	3-8
3.1.4 Environmental Devices	3-10

3.1.5	External Interface	3-13
3.2	Software Architecture	3-15
3.2.1	Basic Software Architecture.....	3-15
3.2.2	CPS Block	3-18
3.2.3	OAM Blocks.....	3-21
CHAPTER 4. Message Flows		4-1
4.1	Call-Processing Message Flows	4-1
4.2	Data Message Flow	4-21
4.3	Network Synchronization Flow	4-22
4.4	Alarm Signal Flow	4-23
4.5	Loading Flow	4-24
4.6	Operation and Maintenance Message Flow	4-25
CHAPTER 5. Supplementary Functions and Tools		5-1
5.1	Web-EMT	5-1
5.2	CLI	5-2
ABBREVIATION		I
A ~ C		I
D ~ G		II
H ~ M		III
N ~ Q		IV
R ~ T		V
U ~ W		VI

LIST OF FIGURES

Figure 1.1	Samsung LTE Network Configurations.....	1-2
Figure 1.2	Functions of E-UTRAN and EPC.....	1-4
Figure 2.1	Indoor eNB + L8HU Installation.....	2-2
Figure 2.2	Outdoor eNB + L8HU Installation.....	2-3
Figure 2.3	LTE eNB System Interface Architecture.....	2-18
Figure 2.4	UE eNB Protocol Stack.....	2-19
Figure 2.5	eNB ↔ S-GW User Plane Protocol Stacks.....	2-20
Figure 2.6	eNB ↔ MME Control Plane Protocol Stacks.....	2-20
Figure 2.7	eNB ↔ eNB User Plane Protocol Stacks.....	2-21
Figure 2.8	eNB ↔ eNB Control Plane Protocol Stacks.....	2-21
Figure 2.9	eNB ↔ LSM Interface Protocol Stacks.....	2-22
Figure 3.1	Removable eNB's Internal Configuration.....	3-2
Figure 3.2	Outdoor eNB Configuration.....	3-3
Figure 3.3	Configuration.....	3-4
Figure 3.4	L8HU Configuration.....	3-6
Figure 3.5	Power Supply.....	3-8
Figure 3.6	Power Diagram.....	3-9
Figure 3.7	Outdoor eNB's Heat Discharge.....	3-10
Figure 3.8	UADU Heat-Discharge Mechanism.....	3-11
Figure 3.9	Sensors.....	3-12
Figure 3.10	UADU External Interface.....	3-13
Figure 3.11	L8HU External Interface.....	3-14
Figure 3.12	eNB Software Architecture.....	3-15
Figure 3.13	CPS Architecture.....	3-18
Figure 4.1	Attach Process.....	4-2
Figure 4.2	Service Request Process by UE.....	4-4
Figure 4.3	Service Request Process by Networking.....	4-5
Figure 4.4	Detach Process by UE.....	4-6
Figure 4.5	Detach Process by MME.....	4-8
Figure 4.6	X2-based Handover Process.....	4-9
Figure 4.7	S1-based Handover Process.....	4-11
Figure 4.8	E-UTRAN-UTRAN PS Handover Process.....	4-14
Figure 4.9	UTRAN-E-UTRAN PS Handover Process.....	4-16
Figure 4.10	CS Fallback to UTRAN Process (UE in Active Mode, No PS HO Support).....	4-18
Figure 4.11	CS Fallback to GERAN Process (UE in Active Mode, No PS HO Support).....	4-19

TABLE OF CONTENTS

Figure 4.12	eNB System Control and Traffic Flow	4-21
Figure 4.13	eNB Network Synchronization Flow.....	4-22
Figure 4.14	eNB System Alarm Flow	4-23
Figure 4.15	Loading Signal Flow.....	4-24
Figure 4.16	Operation and Maintenance Signal Flow	4-25
Figure 5.1	Web-EMT Interface.....	5-1

CHAPTER 1. Overview of Samsung LTE System

1.1 Introduction to Samsung LTE System

The Samsung LTE system is a wireless network system supporting 3GPP Long Term Evolution (3GPP LTE; hereafter, LTE) based services. It improved the disadvantages of low transmission speed and the high cost of the data services provided by the existing 3GPP mobile communication system. The Samsung LTE system is a next generation wireless network system that can provide high-speed data services at a low cost regardless of time and location.

The Samsung LTE system supports the downlink Orthogonal Frequency Division Multiple Access (OFDMA) transmission technology and the uplink Single Carrier (SC) FDMA transmission technology in Frequency Division Duplex (FDD) mode, and supports a scalable bandwidth for supporting various spectrum allocations to provide high-speed data services. In addition, system performance and capacity have increased as a result of high-performance hardware; the Samsung LTE system can easily accommodate a variety of functions and services.

The Samsung LTE system consists of the evolved UTRAN Node B (eNB), Evolved Packet Core (EPC), and LTE System Manager (LSM). The eNB is a system between the UE and EPC, and processes packet calls by connecting to the User Equipment (UE) wirelessly in accordance with the LTE Air standards. The EPC is between the eNB and the Packet Data Network (PDN), and performs various control functions. The EPC consists of the Mobility Management Entity (MME), the Serving Gateway (S-GW), and PDN Gateway (P-GW). The LSM also provides an interface with an operator, functions to manage software, configurations, performance, and failures as well as an ability to act as a Self-Organizing Network (SON) server.



Supported System Specifications

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

1.2 Samsung LTE Network Configuration

The Samsung LTE system consists of eNB, LSM, and EPC (MME, S-GW, P-GW), and its network configurations are shown below.

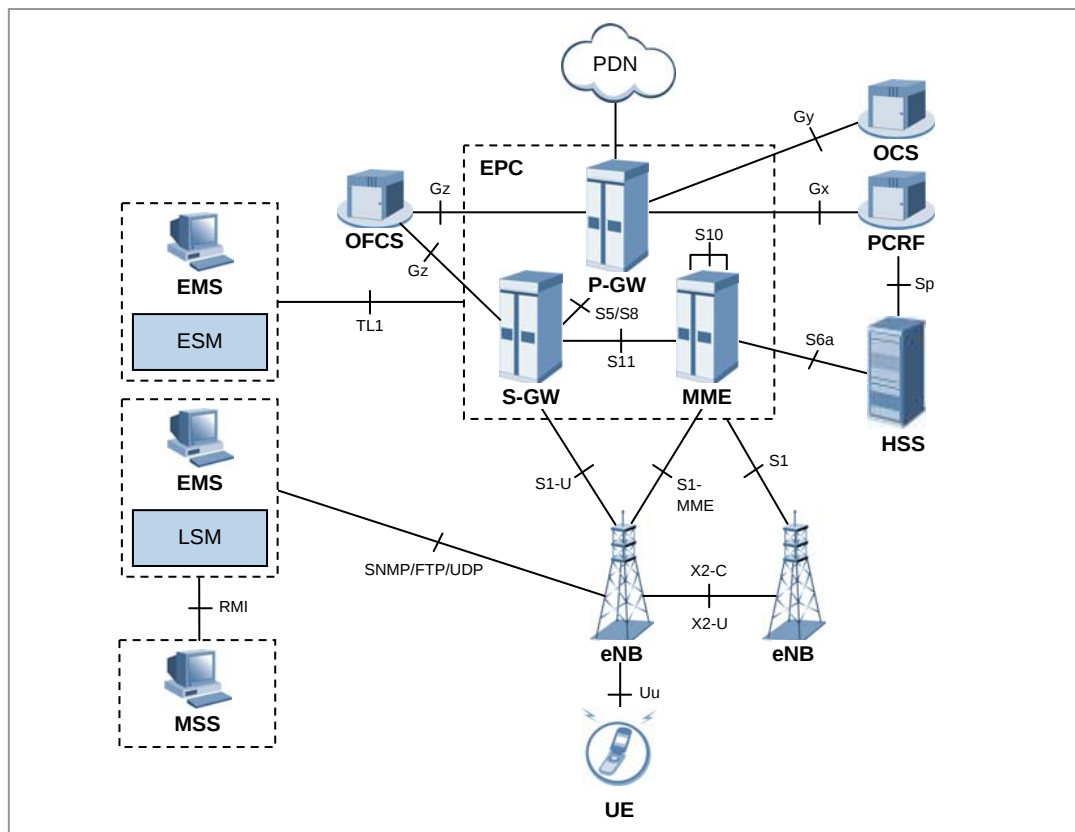


Figure 1.1 Samsung LTE Network Configurations

evolved UTRAN Node-B (eNB)

The eNB is located between the UE and EPC. It processes packet calls by connecting to the UE wirelessly according to the LTE Air standard. The eNB performs functionalities such as 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.

It also performs handovers interoperating with the EPC.

Evolved Packet Core (EPC)

The EPC is a system between the eNB and PDN, consisting of the MME, S-GW and P-GW. The MME processes control messages through the eNB and the NAS signaling protocol, and processes the control functions for the control plane, such as mobility management, tracking area list management, and bearer and session management for UEs.

The S-GW carries out the anchor function in the user plane between the 2G/3G access system and the LTE system, and manages the packet transport layer for downlink/uplink data.

The P-GW allocates an IP address to the UE. For mobility between the LTE system and the non-3GPP access system, the P-GW carries out the anchor function and manages the charging and transmission rate according to the service level.

LTE System Manager (LSM)

The LSM provides an interface to perform operations and maintenance on the eNB by the operator, functions to manage software, configurations, performance, and failures as well as an ability to act as a Self-Organizing Network (SON) server.

EPC System Manager (ESM)

The ESM provides the user interface for the operator to run and maintain the MME, S-GW, and P-GW as system management activities.

Master SON Server (MSS)

The MSS interoperates with the local SON server as its higher node, performing the optimized interoperation for the multi-LSM. The MSS can work with OSS (Operating Support System) 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 creates policy rules to dynamically apply the QoS (Quality of Service) and accounting policies differentiated by service flow, or creates the policy rules that can be applied commonly to multiple service flows. The IP edge includes the PCEF (Policy and Charging Enforcement Function), which allows implementation of policy rules sent from the PCRF per service flow.

Online Charging System (OCS)

The OCS sends/receives charging information required for a subscriber's online charging during calls.

Offline Charging System (OFCS)

The OFCS stores offline charging data and provides subscriber charging information.

1.3 LTE System Functional Architecture

The eNB manages UEs, which are in connected mode, at the AS (Access Stratum) level. The MME manages UEs, which are in idle mode, at the NAS (Non-Access Stratum) level, and the P-GW manages user data at the NAS level as well as working with other networks. The functional architecture of E-UTRAN eNB, MME, S-GW, and P-GW according to the 3GPP standards is shown below. The eNB is structured in layers while the EPC is not.

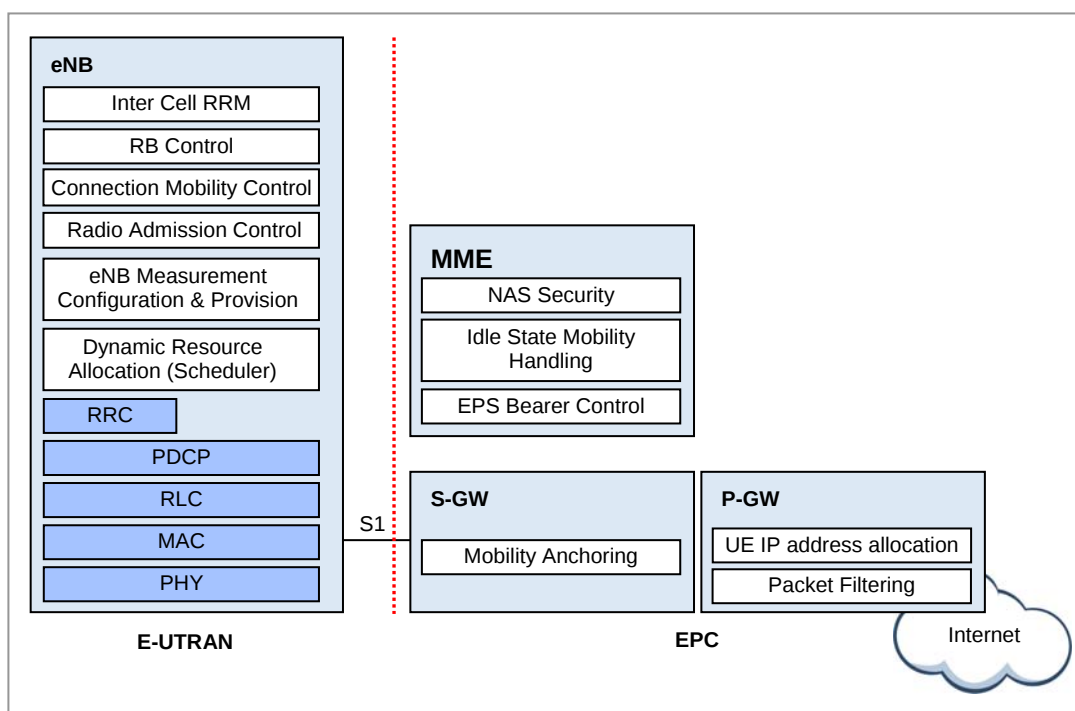


Figure 1.2 Functions of E-UTRAN and EPC

eNB

The eNB serves the E-UTRAN (Evolved UTRAN), a wireless access network in the LTE system.

The eNBs are connected through the X2 interface whereas the eNB and EPC are connected through S1 interface.

The eNB's wireless protocol layers are divided into Layer 2 and Layer 3. Layer 2 is subdivided into the MAC (Media Access Control) layer, RLC (Radio Link Control) layer, and PDCP layer, each operating independently. Layer 3 has the RRC layer.

The MAC layer distributes wireless resources to each bearer according to its priority, and carries out the multiplexing function and the HARQ function for the data received from the multiple upper logical channels.

The RLC layer carries out the following functions.

- Reconstructs the data received from the PDCP layer in accordance with the size specified by the MAC layer (segmentation and reassembly).
- When data transmission fails in the lower layer, requests retransmission to recover them (ARQ).
- Reorders the data recovered by performing HARQ in the MAC layer.

The PDCP layer carries out the following functions.

- Compresses and decompresses headers
- Encrypts and decrypts the user plane and control plane data
- Protects and verifies data integrity of the control plane
- Transmits data and manages serial numbers
- Removes data based on a timer as well as removing duplicates

The RRC layer is responsible for managing mobility in the wireless access network, keeping and controlling the RB (Radio Bearer), managing RRC connections, and sending system information.

Mobility Management Entity (MME)

The MME works with the E-UTRAN (eNB), handling S1-AP (S1 Application Protocol) signaling messages in the SCTP (Stream Control Transmission Protocol) base to control call connections between the MME and eNB as well as handling NAS signaling messages in the SCTP base to control mobility and call connections between the UE and EPC.

The MME also works with the HSS to obtain, modify and authenticate subscriber information, and works with the S-GW to request assignment, release and modification of bearer paths for data routing and forwarding using the GTP-C protocol.

The MME can work with the 2G and 3G systems, SGSN, and MSC to provide mobility, HO (Handover), CS (Circuit Service) fallback, and SMS (Short Message Service) services. The MME is also responsible for managing mobility between eNBs, idle-mode UE reachability, TA (Tracking Area) list as well as for P-GW/S-GW selection, authentication, and bearer management.

MME supports the handover between MMEs and provides the mobility for the handover between the eNBs.

It also supports the SGSN selection function upon handover to a 2G or 3G 3GPP network.

Serving Gateway (S-GW)

The S-GW carries out the mobility anchor function upon inter-eNB handover and inter-3GPP handover, and processes routing and forwarding of packet data. The S-GW allows the operator to set a different charging policy by UE, PDN or QCI, and manages the packet transport layer for uplink/downlink data. The S-GW also works with the MME, P-GW, and SGSN to support the GTP (GPRS Tunneling Protocol) and PMIP (Proxy Mobile IP).

PDN Gateway (P-GW)

The P-GW works with PCRF to carry out charging and bearer policies, and manage the charging and transmission rate based on the service level. It also provides packet filtering per subscriber, assigns IP addresses to UEs, and manages the packet transmission layer of the downlink data.



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CHAPTER 2. Overview of LTE eNB

2.1 Introduction to LTE eNB

The LTE eNB system is located between the UE and EPC, and interfaces via a wireless connection according to the LTE Air Interface, providing subscribers with wireless communication services. The eNB engages in sending and receiving radio signals with the UE, and handling traffic modulation/demodulation signals. The LTE eNB is also responsible for packet scheduling and wireless bandwidth allocation as well as for handovers by interfacing with the EPC.

It consists of a DU (Digital Unit), i.e., UADU (Universal platform type A Digital Unit) and a RU (Radio Unit), i.e., L8HU (LTE eNB remote radio Head Unit).

The UADU is a 19 inch shelf-type digital unit and can be mounted on a 19 inch rack in an indoor/ outdoor environment.

The L8HU 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 the L9CA. The L8HU has a 2Tx/4Rx structure with optic CPRI support, and can be installed on a wall or pole in an outdoor environment.

The LTE eNB can be installed as shown below:

Indoor eNB + L8HU

The L9CA from the UADU mounted on an indoor 19 inch rack is connected to the L8HU. The L8HU can be installed on a wall or pole.

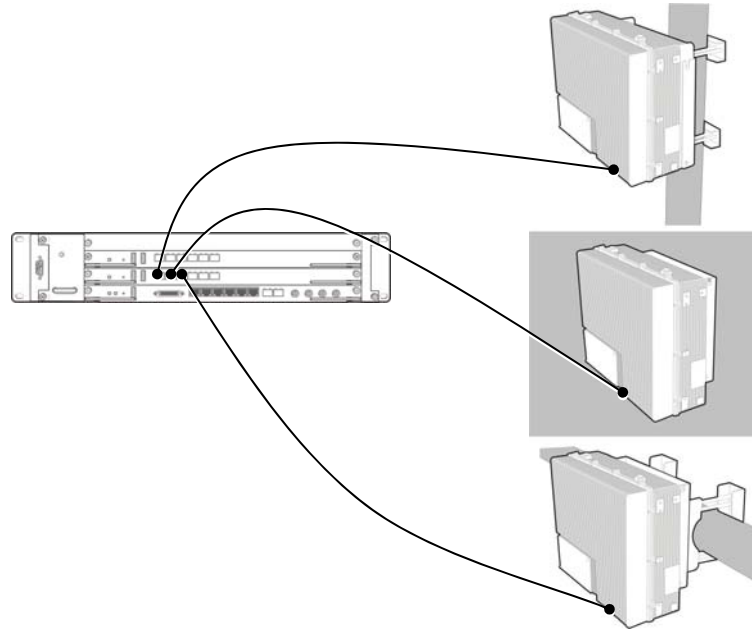


Figure 2.1 Indoor eNB + L8HU Installation

Outdoor eNB + L8HU

The L9CA from the UADU mounted on an outdoor rack is connected to the L8HU. The L8HU can be installed on a wall or pole.

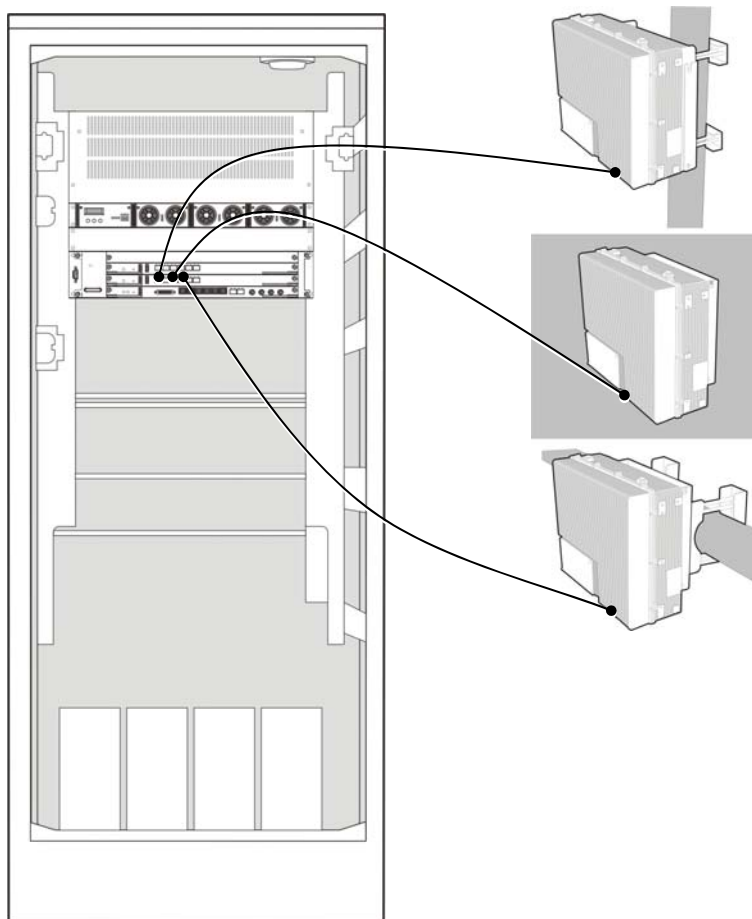


Figure 2.2 Outdoor eNB + L8HU Installation

The LTE eNB system has the following key features:

High Compatibility and Interoperability

Samsung LTE system adheres to specifications released in accordance with the 3GPP standards, providing excellent compatibility and interoperability.

High-Performance Modular Structure

The LTE eNB system uses a high-performance processor and has a modular structure that allows an easy hardware and software upgrade.

Support for Advanced RF and Antenna Solutions

The LTE eNB system adopted a power amplifier to support bandwidth for broadband operation, and also supports MIMO (Multiple Input Multiple Output).

Maintenance with Enhanced Security

The LTE eNB system provides security functions (SNMPv2c, SSH, FTP/SFTP, and HTTPs) for all channels for operation and maintenance. It authenticates operators accessing the system, grants them permissions, and stores their system execution histories as logs.

6Rx Multi Antenna Support

Compared to generic eNBs with 2Rx antennas that receive 2Rx in one sector, Samsung LTE eNB has enhanced reception, receiving antenna signals up to 6Rx from its own sector as well as from the repeater mode.

OFDMA/SC-FDMA Scheme

The LTE eNB performs the downlink OFDMA/uplink SC-FDMA (Single Carrier Frequency Division Multiple Access) channel processing that supports the standard LTE physical layer.

The downlink OFDMA allows the system to transmit data to multiple users simultaneously using the subcarrier allocated to each user. Depending on the channel status and the transmission rate requested by the user, the downlink OFDM can allocate one or more subcarriers to a specific subscriber to transmit data. Moreover, when all subcarriers are divided for multiple users, the FDMA can select and assign to each subscriber a subcarrier with the most appropriate features, distributing resources efficiently and increasing data throughput.

The uplink SC-FDMA, which is similar to the modulation/demodulation method of the OFDMA, minimizes the PAPR (Peak-to-Average Power Ratio) of the transmitter by computing, for each user, DFT (Discrete Fourier Transform) during modulation at the transmitting end, and IDFT (Inverse Discrete Fourier Transform) during demodulation at the receiving end, and continuously assigns frequency resources to users. As a result, it saves the UE's power.

Support for Multiple System Configurations

The LTE eNB supports multiple system and network configurations with a digital unit (UADU) and radio unit (RRH: Remote Radio Head). The digital I/Q and C & M (Control & Maintenance) interface based on the CPRI (Common Public Radio Interface) standard is used between the DU and RU to send and receive data traffic signals and OAM information, and uses optic cable physically.

The UADU and L8HU each have a power supply of DC -48 V.

- **Multiple Configurations for Network Operation**
The LTE eNB supports multiple configurations including RRH (L8HU).
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 the UADU and the RF signal processing component is integrated into the RRH, which becomes a very small and very light single unit. The L8HU can be installed on a wall or pole.
Moreover, as the distance between the 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 Cooling**
Because the RRH is installed outdoors and has an efficient design, it can radiate heat efficiently without any additional cooling system. No additional maintenance cost is needed for cooling the RRH.
- **Loopback Test**
The LTE eNB provides the loopback test function to check whether communication is normal on the Digital I/Q and C & M interface line between the DU and RU.
- **Remote Firmware Downloading**
Operators can upgrade the L8HU and its service by replacing its firmware.
They can download firmware to the L8HU remotely using a simple command from the LSM without visiting field stations.
As a result, the number of visits is minimized, leading to reduced maintenance costs and system operation with ease.
- **Monitoring Port**
Operators can monitor the information for an L8HU using its debug port.

MIMO Support

The LTE eNB supports 2Tx/2Rx or 4Tx/4Rx MIMO by default using multiple antennas. MIMO has the following techniques.

- **SFBC (Space Frequency Block Coding)-Downlink**
 - Reliability for the links is increased. (Note that the peak data rate is not increased.)
 - This technology implements Space Time Block Coding (STBC) not on time but on frequency.
 - For 2 Tx: The method similar to STBC (Alamouti codes) is used.
 - For 4 Tx: Both the SFBC and Frequency Switched Transmit Diversity (FSTD) are used simultaneously.

- SM (Spatial Multiplexing)-Downlink
 - This technology can increase the peak data rate by dividing and sending other data via multiple antenna paths. (Each path uses the same time/frequency resource.)
 - SU (Single User)-MIMO: SM between the eNB and single UE, it increases the UE's peak data rate.
 - MU (Multi-User)-MIMO: SM between the eNB and multiple UEs; it increases cell throughput instead of the UE peak data rate.
 - Open-loop SM: Runs without the UE's PMI (Precoding Matrix Indicator) feedback when the channel changes quickly or is unknown due to the UE's fast mobility.
 - Closed-loop SM: Runs with the UE's PMI feedback received from the eNB when there is channel information due to the UE's slow mobility.
- UL (Uplink) Transmit Antenna Selection-Uplink
 - The UE uses one RF chain and 2Tx antennas. The eNB informs the UE which Tx antenna to use.
 - Closed-loop selection of Tx antenna
- MU (Multi-User) MIMO or Collaborative MIMO-Uplink
 - SM in which two UEs use the same time/frequency resources in the UL simultaneously to transmit different data.
 - Each UE uses a single Tx antenna.
 - The eNB selects two orthogonal UEs.
 - There is an increase in overall cell throughput, but not in each UE's peak data rate.

2.2 Key Functions

Samsung LTE eNB has the following key features.

- Physical layer processing
- Call processing
- IP processing
- SON
- Convenient operation and maintenance

2.2.1 Physical layer processing

The LTE eNB sends/receives data via wireless channels between the eNB and UE.

The eNB handles the following:

- Downlink reference signal generation/transmission
- Downlink synchronization signal generation/transmission
- Channel encoding/decoding
- Modulation/demodulation
- Resource allocation and scheduling
- Link adaptation
- HARQ
- Power control
- ICIC
- MIMO

Downlink reference signal generation/transmission

The reference signal is used to demodulate downlink signals in the UE, and to measure the characteristics of the channel for scheduling, link adaptation, and handover.

Cell-specific and UE-specific reference signals are used when transmitting non-MBSFN.

The cell-specific reference signal is used to measure the quality of the channel, calculate the MIMO rank, perform MIMO precoding matrix selection, and measure the strength of the signals for handover. To operate MIMO, a different reference signal is sent for each antenna path.

Downlink Synchronization Signal Generation/Transmission

The synchronization signal is used to perform the initial synchronization when the UE starts to communicate with the base station. It can be PSS (Primary Synchronization Signal) or SSS (Secondary Synchronization Signal). The UE obtains cell identify through the synchronization signal, and other cell information through the broadcast channel.

Transmission in the synchronization signal and broadcast channel occurs at 1.08 MHz of the cell's channel bandwidth as the UE can identify cell ID and other basic information regardless of the eNB's transmission bandwidth.

Channel encoding/decoding

The LTE eNB encodes/decodes the channel to correct channel errors over the wireless channel. To do this, the LTE eNB uses turbo coding and 1/3 tail-biting convolutional coding. Turbo coding is used primarily to transmit large downlink/uplink data packets, and 1/3 tail-biting convolutional coding to transmit downlink/uplink control information and for the broadcast channel.

Modulation/Demodulation

When receiving downlink data from the upper layer, the LTE eNB processes it through the baseband procedure of the physical layer and then transmits it via a wireless channel. At this time, to send the baseband signals as far as they can go via the wireless channel, the LTE eNB modulates them and sends them on a specific high frequency bandwidth. For the uplink, the eNB demodulates the data transmitted over the wireless channel from the UE to a baseband signal, which is then decoded.

Resource Allocation and Scheduling

For multiple access, the LTE uses the OFDMA for downlink and the SC-FDMA for uplink. Both schemes allocate 2-dimensional time/frequency resources to multiple UEs in a cell, allowing a single eNB to communicate with the multiple UEs simultaneously.

When in MU-MIMO mode, several UEs can use the same resources at the same time as an exceptional case. Allocating cell resources to multiple UEs is called ‘scheduling’ and each cell has an independent scheduler.

The scheduler is designed to consider the channel environment, the requested data transmission rate and other various QoS factors of each UE, and perform an optimal resource allocation to provide maximum total cell throughput. It also can share information with other cell schedulers via the X2 interface to reduce interferences with the other cells.

Link Adaptation

The transmission rate and channel environment in the wireless channel change according to circumstances. Link adaptation is a feature to increase transmission speed or maximize overall cell throughput using channel circumstances when they are known.

MCS (Modulation Coding Scheme) is a link adaptation method that sets the modulation type and channel coding rate depending on the channel circumstances. If the channel circumstances are good, the MCS increases the number of transmission bits per symbol using high-order modulation, such as 64 QAM. If the circumstances are bad, it uses low-order modulation, such as QPSK, and a low coding rate to minimize channel errors.

The MCS can run in MIMO mode if the channel environment allows MIMO, increasing the user’s peak data rate or cell throughput.

If channel information turns out to be different from the actual case, or if the order given to the modulation or coding rate for the channel circumstances is higher than necessary, an error can occur, but be recovered by HARQ.

HARQ

HARQ is a technique for physical layer retransmission using the stop-and-wait protocol. The LTE eNB runs the HARQ, retransmitting or combining frames in the physical layer in order to increase throughput so that the impact from changes of the wireless channel environment or interference signal level can be minimal. The LTE uses the IR (Incremental Redundancy)-based HARQ. The CC (Chase Combining) method is treated as a special case of the IR scheme. It uses the asynchronous IR for downlink, and the synchronous IR for uplink.

Power Control

Power control refers to adjusting the transmission power level required to transmit a specific data rate. Too much power causes interferences. Too little power increases the error rate, causing a retransmission or delay.

Power control is less important in the LTE than in the CDMA, but a proper power control can enhance the LTE's system performance. The LTE uses the SC-FDMA scheme for uplink and eliminates the near-far problem from the CDMA, but the UEs should transmit with optimal power to avoid interference with neighbor cells as the high level of interference with the neighbor cells can worsen the uplink performance. The LTE uplink can lower the inter-cell interference level by adjusting the UE power. The downlink can lower the inter-cell interference level by transmitting with optimal power according to the UE location and MCS, increasing overall cell throughput.

Inter-Cell Interference Coordination (ICIC)

Unlike the CDMA, the LTE does not have intra-cell interference. This is because UEs in a cell use orthogonal resources and thus there is no interference between them. However, in the event that the adjacent cells are considered, unavoidable interference occurs when other UEs use the same resource. Since this symptom is severe between the UEs located on a cell edge, performance on the cell edge may be degraded. Inter-cell interference is not severe for the UEs located close to the eNB because they receive much less interference from the adjacent eNBs than the UEs located on the cell edge. A technique used to address the inter-cell interference problem on the cell edge is ICIC.

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 the UE's location in the cell. To prevent interference due to resource conflict on the cell edge, ICIC transmits scheduling information between base stations via the X2 interface. When the neighbor cell's interference signal strength is too strong, ICIC notifies other base stations to control the interference, improving overall cell performance.

MIMO

The LTE eNB supports 2Tx/2Rx or 4Tx/4Rx MIMO by default using multiple antennas. To achieve this, there must be in the eNB channel card the RF part that can separately process the baseband part and each path for MIMO processing. The LTE eNB provides high-performance data services by supporting several types of MIMO.

2.2.2 Call Processing

Cell Information Transmission

The LTE eNB periodically transmits, within the cell range being served, system information, i.e., the MIB (Master Information Block) and SIBs (System Information Blocks), which are then received by UEs to process calls appropriately.

Call Control and Air Resource Assignment

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

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

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

Handover Processing

The LTE eNB supports intra-frequency or inter-frequency handover between intra-eNB cells, X2 handover between eNBs, and S1 handover between eNBs, and carries out the signaling and bearer processing functions required for handover. At intra-eNB handover, handover-related messages are transmitted via internal eNB interfaces; at X2 handover, via the X2 interface; at S1 handover, via the S1 interface.

The eNB carries out the data forwarding function to minimize user traffic disconnections at X2 and S1 handovers. The source eNB provides two forwarding methods to the target eNB, direct forwarding via the X2 interface and indirect forwarding via the S1 interface.

The eNB allows the UE to receive traffic without loss through the data forwarding method at handover.



NOTE

Handover Procedure

For more on the handover procedure, refer to Chapter 4. Message Flow.

Admission Control (AC)

The LTE eNB provides capacity-based and QoS-based admission control for bearer setup requests from the EPC to avoid system overload. Capacity-based admission control and QoS-based admission control operate as follows respectively.

- Capacity-based admission control
There is a threshold for the maximum number of connected UEs (new calls/handover calls) and a threshold for the maximum number of connected bearers that can be allowed in the eNB. When a call setup is requested, the permission is determined depending on whether the connected UEs and bearers exceed the thresholds.

- QoS-based admission control

The eNB provides the function for determining whether to permit 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 carries out the ARQ function for the RLC Acknowledged Mode (AM) only. The RLC can increase reliability of data communications by dividing the Service Data Unit (SDU) into the Protocol Data Unit (PDU) prior to transmission, and retransmitting the packets according to ARQ feedback from the receiver.

QoS Support

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

In the wireless section, it carries out retransmission to satisfy the rate control due to the GBR/MBR/AMBR value, priority of bearer defined in the QCI, and scheduling considering packet delay budget, and Packet Loss Error Rate (PLER).

In the backhaul section, the eNB carries out QCI-based packet classification, QCI to DSCP mapping, and marking for the QoS. The eNB provides queuing based on mapping results, and each queue transmits packets to the EPC according to strict priority, etc.

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

2.2.3 IP Processing

IP QoS

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

The LTE eNB supports eight backhaul QoS classes as well as mapping between the user traffic service class and the backhaul QoS class. It also supports mapping between the Differentiated Services Code Points (DSCP) and the 802.3 Ethernet MAC service classes.

IP Routing

The LTE eNB provides several Ethernet interfaces and stores in the routing table information on which Ethernet interface IP packets will be routed.

The LTE eNB's routing table is configured by the operator. The table configuration and its setting are similar to standard router settings.

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

Ethernet/VLAN Interfacing

The LTE eNB provides Ethernet interfaces, and supports static link grouping, VLAN Virtual Local Area Network(VLAN), and Ethernet Class of Service(CoS) functions that comply with IEEE 802.3ad for Ethernet interfaces. A MAC bridge defined in IEEE 802.1D is excluded.

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

2.2.4 SON

System Self-Configuration and Self-Establishment

The self-configuration and the self-establishment automatically configure and establish radio parameters between the power-on stage and the service stage to minimize efforts in installing a base station. The detailed functions are as follows.

- Self-configuration
 - Initial PCI (Physical Cell Identity) self-configuration
 - Initial neighbor information self-configuration
 - Initial PRACH (Physical Random Access Channel) self-configuration
- Self-establishment
 - Automatic IP address acquisition
 - Automatic OAM connectivity
 - S/W and Configuration data loading
 - Automatic S1/X2 setup
 - Self-test

Self-Optimization

- PCI auto-configuration

The SON server of the LSM provides the function for allocating the initial PCI in the self-establishment procedure of a new eNB, and the function for detecting a problem automatically and selecting, changing, and setting a proper PCI when a PCI collision/confusion occurs with the adjacent cells during operation.
- Automatic Neighbor Relation (ANR) optimization

ANR optimization minimizes the network operator's effort to maintain the optimal NRT by dynamically managing the Neighbor Relation Table (NRT) according to the addition/removal of neighbor cells. It needs to automatically configure each eNB's initial NRT, and recognize environment changes, such as cell addition/removal or new eNB installations during operation to maintain the optimal NRT. In other words, the ANR function updates the NRT for each eNB by automatically recognizing the topology change such as new adjacent cell or eNB installation/removal and adding or removing the Neighbor Relation (NR) to or from a new adjacent cell.
- Mobility robustness optimization

The mobility robustness optimization function is the function for improving handover performance in the eNB by recognizing the problem that handover is triggered at the incorrect time (e.g., 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.
- Energy Saving Management (ESM)

The energy saving feature helps reduce the LTE eNB's power consumption. The ESM adjusts power consumption automatically according to the specified schedule or through traffic quantity analysis. The basic principle is that power consumption is reduced by limiting the number of used Resource Blocks (RBs) and adjusting the PA bias voltage.

- Random Access Channel (RACH) optimization
RACH optimization (RO) can minimize access delay and interference by dynamically managing parameters related to random access. The RO function is divided into the initial RACH setting operation and the 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.

2.2.5 Convenient Operation and Maintenance

The LTE eNB works with management systems (LSM, Web-EMT, CLI) to operate maintenance activities, such as resetting/restarting a system as well as managing system configurations, failure/status/diagnosis of system resources and services, statistics on system resources and various performance data, and security for system access and operation.

Graphics and Text Based Console Interfaces

The LSM manages the entire eNB system using the Database Management System (DBMS). The eNB also works with a console terminal to allow the operator to connect directly to the Network Element (NE), not through the LSM, for operation and maintenance activities. The operator can choose between the graphic-based console interface (Web-EMT, Web-based Element Maintenance Terminal) or the text-based Command Line Interface (CLI) to suit operational convenience and purpose.

The operator can access the console interfaces without separate software. For the Web-EMT, the operator can log in to the system using Internet Explorer. For the CLI, the operator can log in to the system using the telnet or Secure Shell (SSH) in the command window.

Tasks such as managing configurations and operational information, failures and statuses, and monitoring statistics can be done through the terminal. However, increasing/decreasing resources or configuring neighbor lists in which multiple NEs are related can only be performed using the LSM.

Operator Authentication

The eNB can authenticate system operators and manage their privileges.

An operator accesses the eNB using the operator's account and password through the CLI.

The eNB grants an operational privilege in accordance with the operator's level.

The eNB logs successes/failures of access to the CLI, activities during the login, etc.

Maintenance with Enhanced Security

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

Online Software Upgrade

When a software package is upgraded, the EPC can upgrade the existing package while it is still running. A package upgrade is performed in the following steps: download new package (Add) and change to the new package (Change).

When upgrading the package, the service stops temporarily during the 'change to the new package' step to exit the existing process and start the new process. But the operating system does not restart, so it can provide the service within several minutes.

After upgrading the software, the eNB updates the package stored in the internal nonvolatile storage.

Call Trace

When tracing calls for a specific UE using the MME, the eNB transmits to the LSM a signaling message for the call in the UE.

OAM Traffic Throttling

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

For the 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. For the 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.

2.3 Specifications

Capacity

The following table shows LTE eNB's capacity.

Item	Specifications
Air specification	FDD LTE
Operating Frequency	DL: 728~746 MHz UL: 698~716 MHz
Channel Bandwidth	5 MHz
Capacity	1/2 Carrier/3Sector
RF Power per Sector	40 W (2 Tx Path)
Backhaul Links	100/1000 Base-T (RJ-45, 2 ports) 1000 Base-SX/LX (SFP, 2 ports)
DU-RRH Interface	CPRI 4.0 (Optic)
Holdover	24 h

Input Power

The following table shows the power specifications of the LTE eNB. The LTE eNB complies with UL60950 safety standard for electrical equipment.

Item	Specifications
System Input Voltage	220 V AC (input voltage of the single outdoor station system)
UADU	-48 VDC
L8HU	

Dimensions and Weight

The following table shows the size and weight of LTE eNB.

Item		Specifications
Size(mm)	UADU	434(W) × 385(D) × 88(H)
	L8HU	450(W) × 175(D) × 390(H)
Weight (kg)	UADU	12 or less
	L8HU	23 or less

The following table shows the size and weight of the outdoor rack of LTE eNB.

Item	Specifications
Size (mm)	700 (W) × 820 (D) × 1,800 (H)
Weight (kg)	Approx. 370 or less (with 1 set of battery)

GPSR Specifications

The following table shows the features of LTE eNB's GPSR (GPS Receiver).

Item	Specifications
Received Signal from GPS	GPS L1 Signal
Accuracy/Stability	0.02 ppm

Ambient Conditions

The following table shows the ambient conditions and related standard of the outdoor rack.

Item	Range	Applicable Standard
Temperature	-20~50°C	GR-487-CORE Sec.3.26
Humidity	5~95% The moisture content must not exceed 30 g per 1 m ³ of air.	GR-63-CORE Sec.4.1.2 GR-487-CORE Sec.3.34.2 (Issue 2, April, 2002) R3-204
Altitude	-60~1,800 m	GR-63-CORE Sec.4.1.3
Earthquake	Earthquake (Zone4)	GR-63-CORE Sec.4.4.1
Vibration	- Office Vibration - Transportation Vibration	GR-63-CORE Sec.4.4.4 GR-63-CORE Sec.4.4.5
Noise (sound pressure level)	Less than 65 dBA measured at point 1.5 m above the floor and 0.6 m all around	GR-63-CORE Sec.4.6 GR-487-CORE Sec.3.29

The following table shows the ambient conditions and related standard of the L8HU.

Item	Range	Applicable Standard
Temperature	-40~50°C	GR-487-CORE Sec.3.26
Humidity	10~95% The moisture content must not exceed 30 g per 1 m ³ of air.	GR-487-CORE Sec.3.34.2 (Issue 2, April, 2002) R3-204
Altitude	-60~1,800 m	GR-63-CORE Sec.4.1.3
Earthquake	Earthquake (Zone4)	GR-63-CORE Sec.4.4.1
Vibration	- Office Vibration - Transportation Vibration	GR-63-CORE Sec.4.4.4 GR-487-CORE Sec.3.35.5 GR-63-CORE Sec.4.4.5 GR-487-CORE Sec.3.35.3
Noise (sound pressure level)	FAN less	-
Electromagnetic Interference (EMI)	Complied	FCC Title47 Part 15 Class B GR-1089-CORE EN 55022, EN 55024 EN 301 489

2.4 System-to-System Interface

2.4.1 Interface Architecture

The LTE eNB system provides the following interface to allow interoperation between NEs.

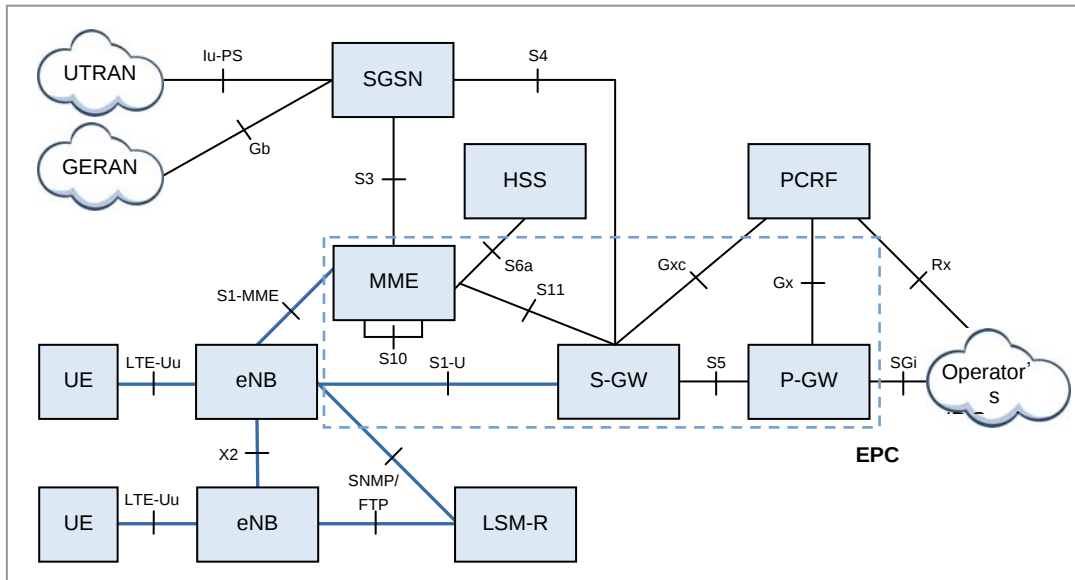


Figure 2.3 LTE eNB System Interface Architecture

- **Interface between UE and eNB**
A physical connection between the UE and eNB is established via radio according to LTE Air Interface, and the interface standards should satisfy the LTE Uu interface. The UE interfaces and communicates data with the eNB via radio.
- **Interface between eNB and EPC**
A physical connection between the eNB and EPC is established through the FE (Fast Ethernet) and GE (Gigabit Ethernet), and the interface standards should satisfy the interface between the S-GW and LTE S1-U for the user plane, and the interface between the MME and S1-MME for the control plane.
- **Interface between eNBs**
A physical connection between the eNBs is established through the FE and GE, and the interface standards should satisfy the LTE X2 interface.
- **Interface between eNB and LSM**
A physical connection between the eNB and LSM is established through the FE and GE, and the interface standards should satisfy the SNMP/FTP interface.

2.4.2 Protocol Stack

The protocol stack between NEs in the eNB system is as follows:

Interface between UE and eNB

The user plane protocol stack consists of PDCP, RLC, MAC, and PHY layers. The user plane is responsible for transmitting user data (e.g., IP packets) received from the higher layer. All protocols in the user plane are terminated in the eNB.

The control plane protocol stack consists of NAS, RRC, PDCP, RLC, MAC, and PHY layers. Located above the wireless protocol, the NAS layer is responsible for UE authentication between the UE and MME, security control, and paging/mobility management of UEs in LTE idle mode.

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

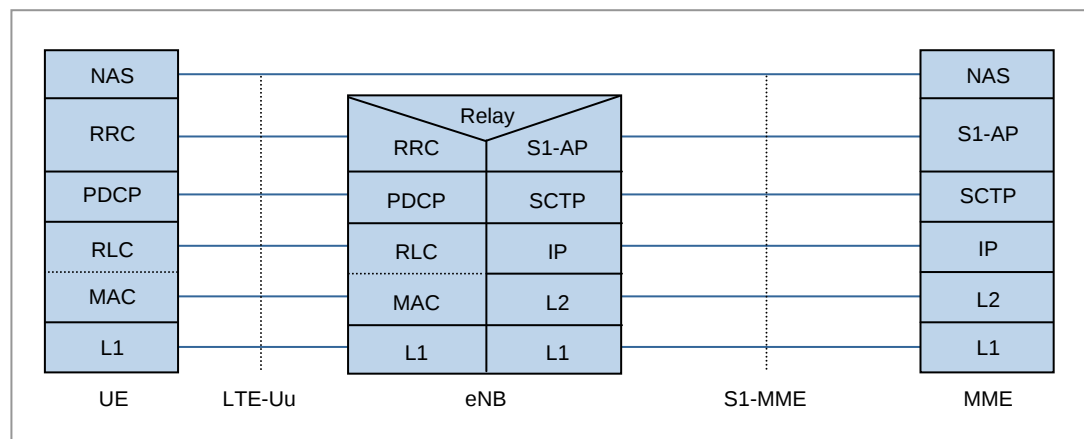


Figure 2.4 UE eNB Protocol Stack

Interface between eNB and EPC

A physical connection between the eNB and EPC is established through the FE and GE, and the interface standards should satisfy the interface between the LTE S1-U and S1-MME. The user plane uses the GTP-U (GTP-User) above the IP, and the control plane uses the SCTP above the IP.

The user plane protocol stacks between the eNB and S-GW are shown below.

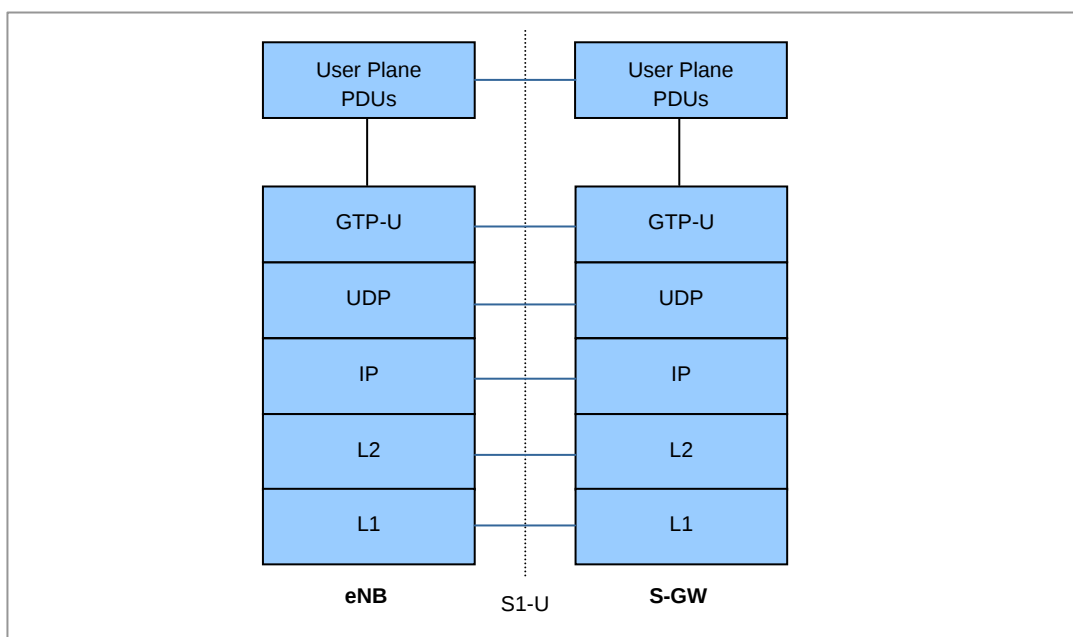


Figure 2.5 eNB ↔ S-GW User Plane Protocol Stacks

The control plane protocol stacks between the eNB and MME are shown below.

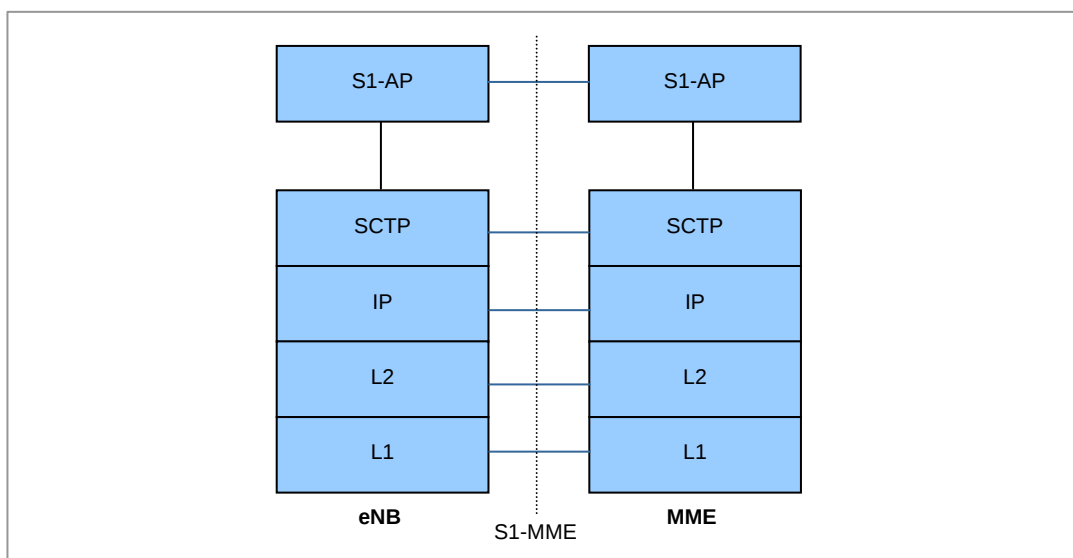


Figure 2.6 eNB ↔ MME Control Plane Protocol Stacks

Interface between eNBs

A physical connection between the eNBs is established through the FE and GE, and the interface standards should satisfy the LTE X2 interface. The user plane protocol stacks between the eNBs are shown below.

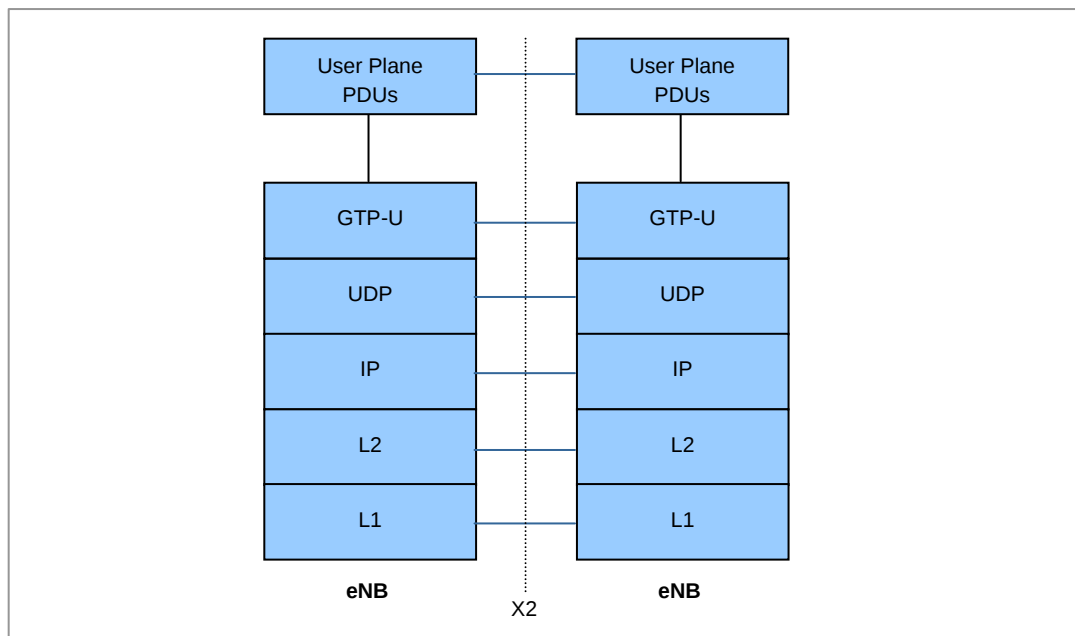


Figure 2.7 eNB ↔ eNB User Plane Protocol Stacks

The control plane protocol stack is shown below.

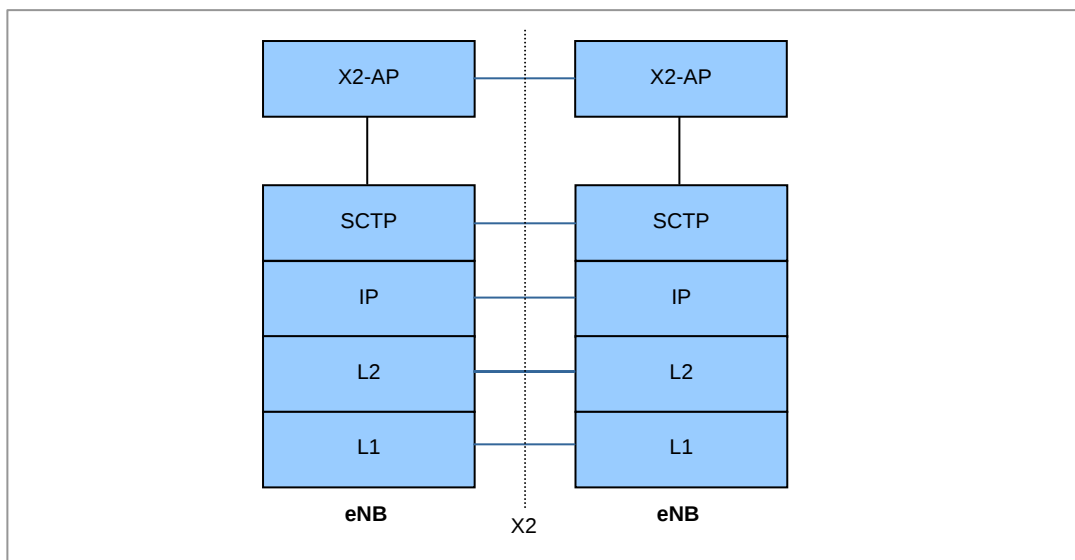


Figure 2.8 eNB ↔ eNB Control Plane Protocol Stacks

Interface between eNB and LSM

A physical connection between the eNB and LSM is established through the FE and GE, and the interface standards should satisfy the FTP/SNMP interface. The interface protocol stacks between the eNB and LSM are shown below.

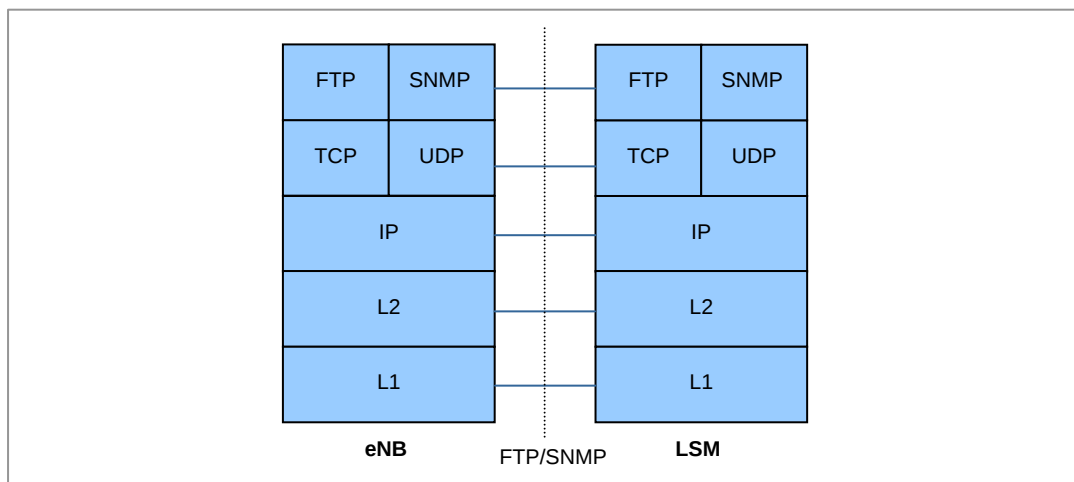


Figure 2.9 eNB ↔ LSM Interface Protocol Stacks

Physical Interface Options

The LTE eNB provides two types (copper and optic) for the EPC interface, which can be selected based on network configurations. The interface can be used in any number according to the LTE eNB capacity and required bandwidth.

The interface types are shown below.

Interface Type	Port Type	Maximum Number of Ports per System
Copper	1000 Base-T (RJ-45)	2
Optic	1000 Base-LX/SX (SFP)	2

CHAPTER 3. LTE eNB Architecture

3.1 Hardware Architecture

The LTE eNB system consists of a digital unit, UADU, and a radio unit, L8HU, of a common platform. The UADU connects with the L8HU through the CPRI, and is capable of 2-carrier/3-sector services.

LTE eNB's Internal Configuration

The following figure shows the internal configuration of the LTE eNB.

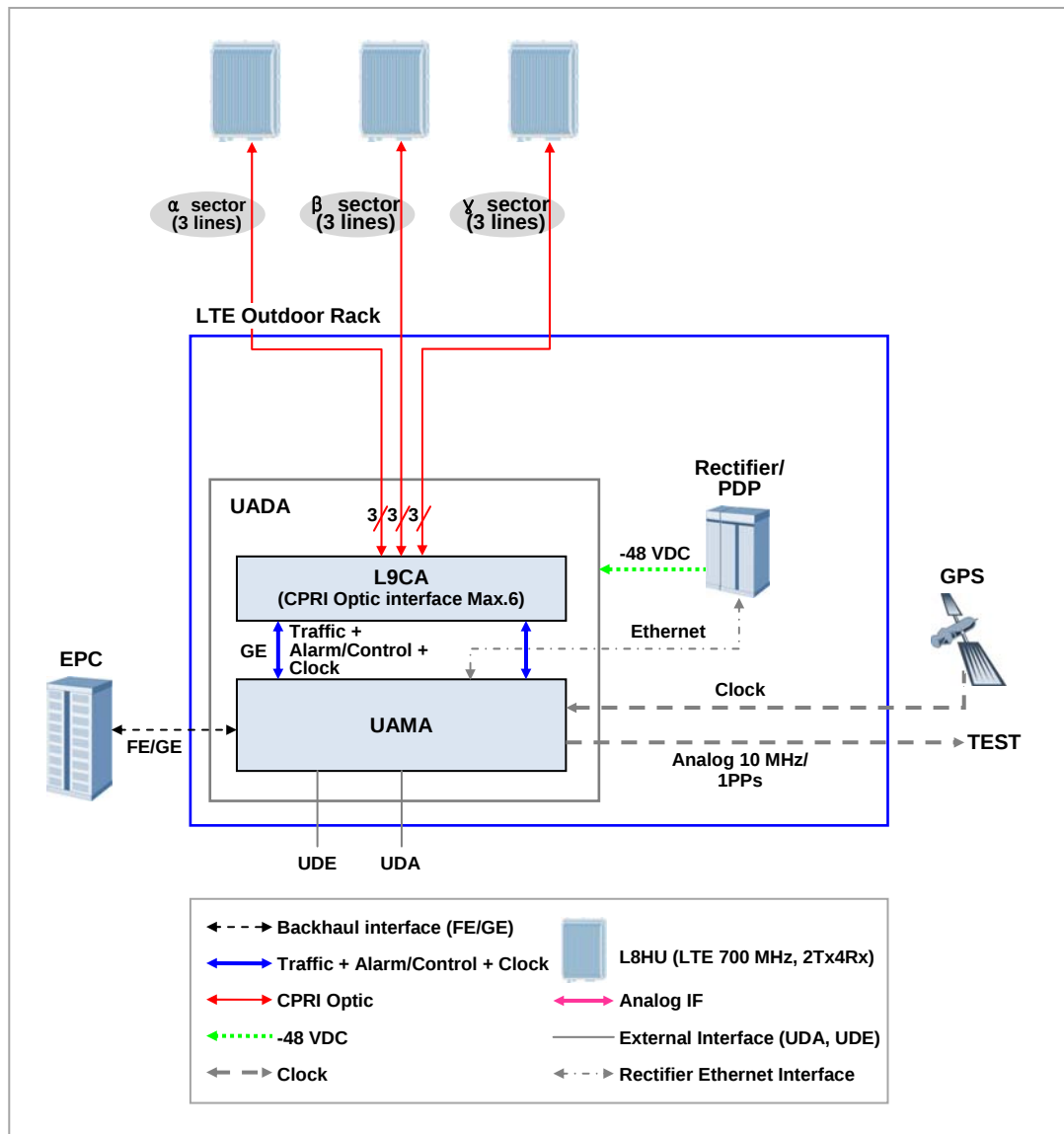


Figure 3.1 Removable eNB's Internal Configuration

2Tx/4Rx is supported by default in the UADU, and up to three L9CAs (LTE eNB Channel card board Assembly) can be mounted additionally. A maximum of 5 MHz 2-carrier/3-sector can be supported.

The L9CA has a capacity of 5MHz 2-carrier/3-sector (2Tx/2Rx) per board, by default. The four slots of the UADU are multi-board type slots where the UAMA carries out the main processor function, network interface function, clock generation and distribution function, provider-requested alarm processing, etc. and the L9CA carries out the modem function. The power module, FAN, and dust filter are also installed.

The L8HU 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 the L9CA. It has a 2Tx/4Rx structure with optic CPRI support.

The following shows the configuration of LTE's outdoor eNB.

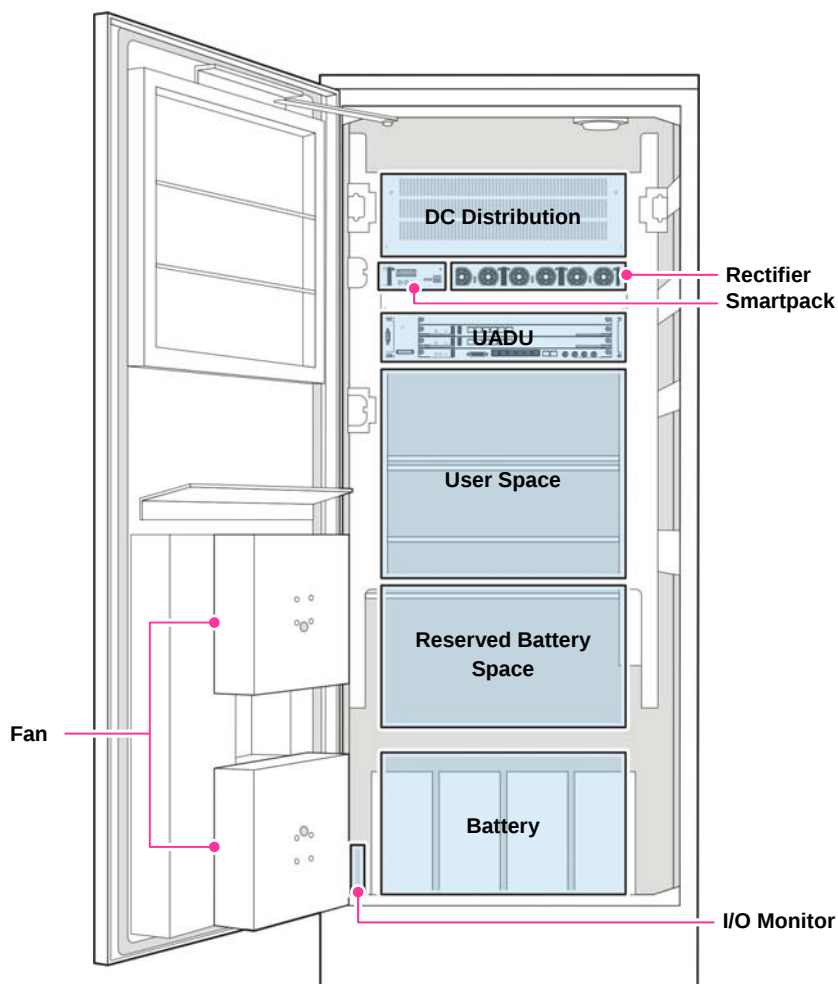


Figure 3.2 Outdoor eNB Configuration

3.1.1 UADU

The following shows the configuration of the UADU.

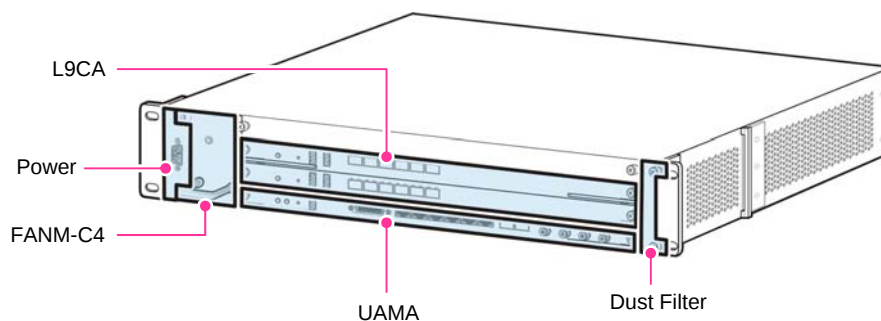


Figure 3.3 Configuration

The UADU is the Multi-board type in which the UAMA that carries out the main processor function, network interface function, and clock creation and distribution function and the L9CA that carries out the modem function are mounted. It consists of the power module, FANM-C4 module, and dust filter.

The UADU is mounted on a 19 inch rack, with fan cooling and EMI available in each unit, and has a capacity of up to 2-carrier/3-sector per a single L9CA. In addition to optic CPRI with the L8HU, up to six optic ports per channel card are available.

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

Board	Quantity	Description
UADB	1	Universal platform type A Digital Backplane board assembly - UADU's backboard - Routing signals for traffic, control, clocks, power, etc.
UAMA	1	Universal platform type A Management board Assembly - Main processor in the system - Resource allocation/operation and maintenance - Alarm collection and report to LSM - Backhaul support (GE/FE) - UADU FAN alarm handling - Provides the interface for rectifier alarms - Provides UDE (User Defined Ethernet) and UDA (User Defined Alarm) - Generates and supplies GPS clocks (sync in & out)
L9CA	Max. 3	LTE eNB Channel card board Assembly - Call processing, resource allocation/operation and maintenance - OFDMA/SC-FDMA Channel Processing - Interface between the L8HU and optic CPRI - Support for optic interface with CPRI RRH (E/O, O/E conversion in CPRI Mux)

UAMA

The UAMA acts as a main processor of the UADU, and is responsible for network and external interfacing, reset, and clock generation/distribution.

- **Main Processor**
The eNB's main processor is a board acting in the topmost role of the eNB, and is responsible for communication path setups between the UE and EPC, Ethernet switching in the eNB, and system operation/maintenance. It also manages the status for all hardware/software in the eNB, allocates and manages resources, collects alarms, and reports all status information to the LSM.
- **Network Interface**
The UAMA directly interfaces with the EPC through the GE/FE and supports a total of four ports (two optic and two copper ports). If only one type of port (either optic or copper) is used, ports not in use can be other UDEs.
- **External Interface**
The UAMA provides the Ethernet interface for UDE in the UADU, and paths for alarm information generated in external devices (additional devices supplied by the provider) as well as reporting alarm information to the LSM.
- **Reset**
The UAMA provides the reset function for each board.
- **Clock Generation and Distribution**
By using the PP2S (even clock), digital 10 MHz signals received from the UCCM (Universal Core Clock Module), the UAMA generates 10 MHz, even, and System Frame Number (SFN) clocks for synchronization and distributes them to the hardware blocks.
These clocks are used to maintain internal synchronization in the eNB and to operate the system.
The UAMA also provides analog 10 MHz and 1 pps for measuring and relaying equipments.
The UCCM transmits time information and location information through the TOD (Time Of Day) path.
If the UCCM fails to receive GPS (Global Positioning System) signals due to an error during system operation, it carries out the holdover function that supplies the normal clocks that have been provided for a specific period of time.

L9CA

The L9CA is responsible for subscriber channel handling and CPRI interfacing.

- **Subscriber Channel Processing Function**
The L9CA modulates the packet data received from the upper processor and transmits it to the RF part via CPRI. In the other direction, it demodulates the packet data received from the RF, converts them to the format which is defined in the LTE standard physical layer specifications, and transmits them to the upper processor.
- **CPRI Interface**
The L9CA interfaces via the L8HU and CPRI.

3.1.2 L8HU

The following shows the configuration of L8HU.

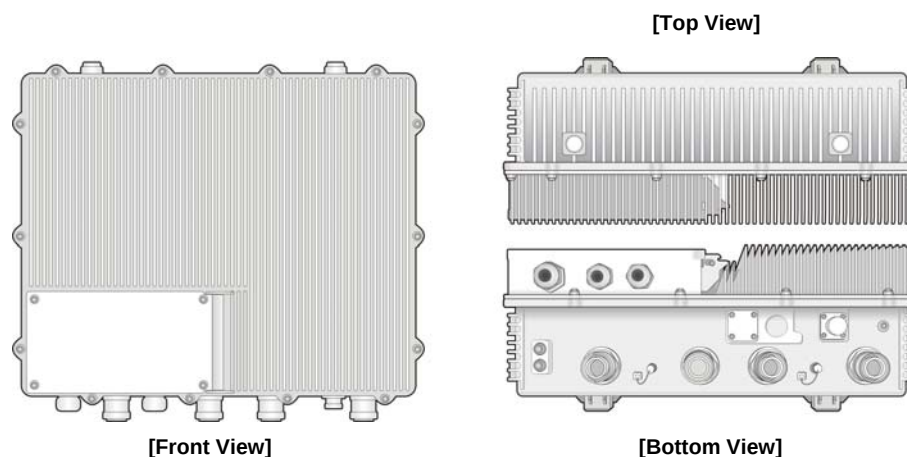


Figure 3.4 L8HU Configuration

By default, the L8HU is installed outdoors for natural cooling.

The L8HU consists of a 2Tx/4Rx RF chain as an integrated RF unit with a transceiver, power amplifier and filter installed in the single outdoor unit. It can support 10 MHz and 15 MHz bandwidth with firmware changes.

In the downlink path, the L8HU performs O/E conversion for the baseband signals received from the UADU 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 up converted through the modulator and then those signals are amplified into high-power RF signals through the power amplifier. The amplified signals are sent to the antenna through the filter part. In the uplink path of the L8HU, the RF signals received through the filter part are amplified low noise in the LNA (Low Noise Amplifier) 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 the CPRI and sent to the UADU. The control signals of the L8HU are transmitted through the control path in the CPRI.

The main functions are as follows

Unit	Description	Configuration
L8HU	LTE eNB remote radio Head Unit - 700 MHz (DL 728~746 MHz, UL 698~716 MHz) - Support for 5 MHz 2Tx4Rx per L8HU - Support for 5 MHz 2-carrier/1-sector - 20 + 20 W per carrier (40 W total) - Up/Down RF conversion - Low-noise amplifier - RF high-power amplification - Spurious wave suppression outside the bandwidth - Includes E/O and O/E conversion modules for optic communications with UADU. - Support for RET (Remote Electrical Tilt)	Distributed type

3.1.3 Power supply

The following shows the configuration of the outdoor eNB's power supply.

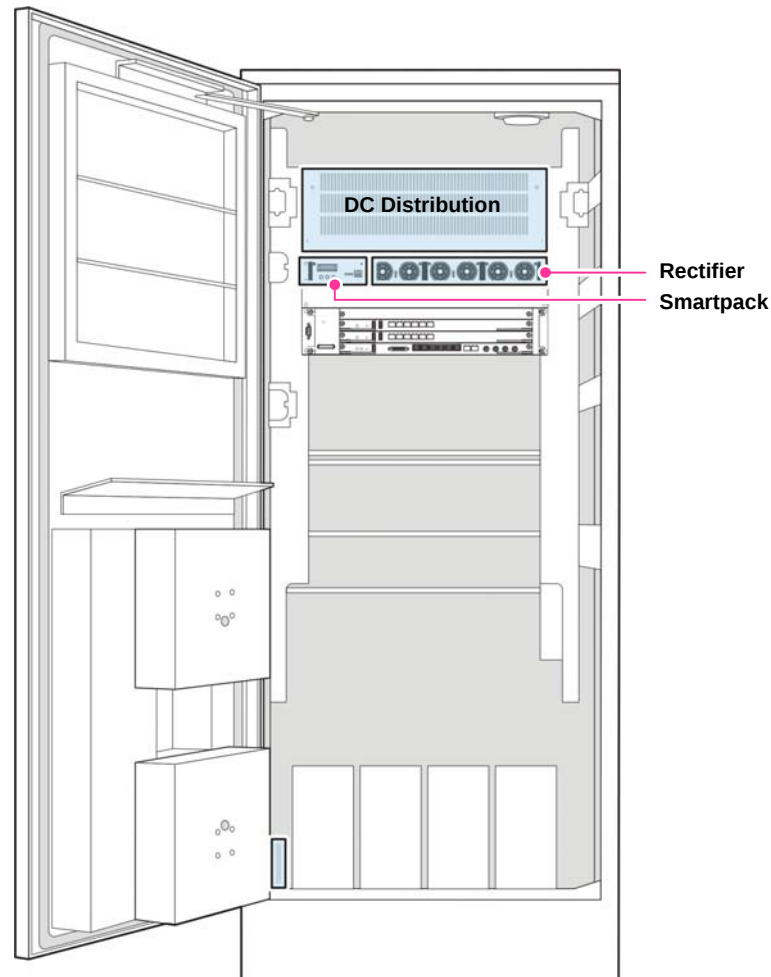


Figure 3.5 Power Supply

Unit	Quantity	Description
DC Distribution	1	Divides the DC power from the rectifier to provide a supply to the UADU, L8HU and additional devices.
Smartpack	1	Controls the rectifier and reports to the UAMA with alarms collected by the I/O monitor.
Rectifier	3	Supplies DC power to the system. Up to three rectifiers can be mounted.

The type of power supplied to the outdoor eNB and the connection points are shown in the power diagram below.

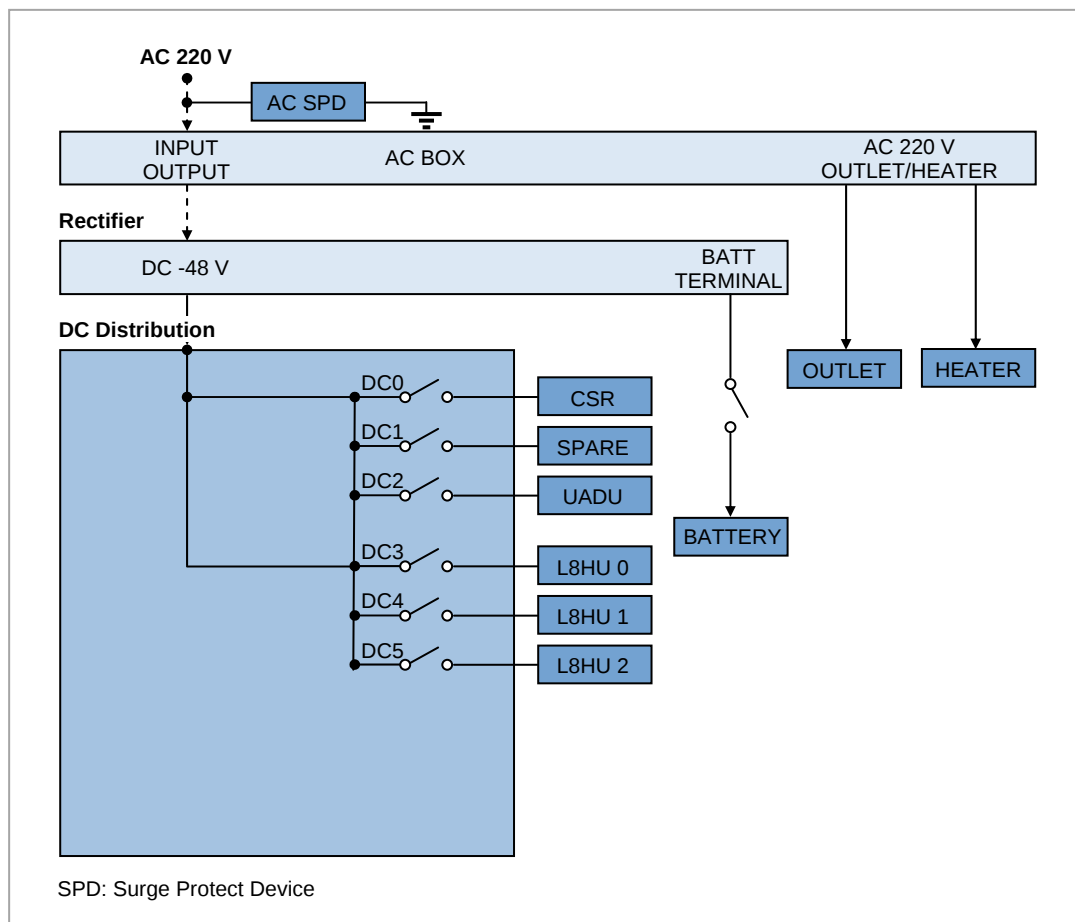


Figure 3.6 Power Diagram

The input power (220 VAC) is directly supplied to the outlet and heater through the AC box, and converted through the rectifier into DC -48 V. DC -48 V goes to the DC distribution, and is distributed through the circuit breaker to the CSR, UADU, L8HU, etc.

3.1.4 Environmental Devices

Mounted on the front door of the outdoor rack, FAN adjusts the system temperature by discharging heated air in the rack outside.

If the system's internal temperature is above the optimum, the smartpack and I/O monitor control the FAN to decrease the temperature. If the system's internal temperature reaches the optimum, the smartpack and I/O monitor adjusts the FAN speed to control the temperature.

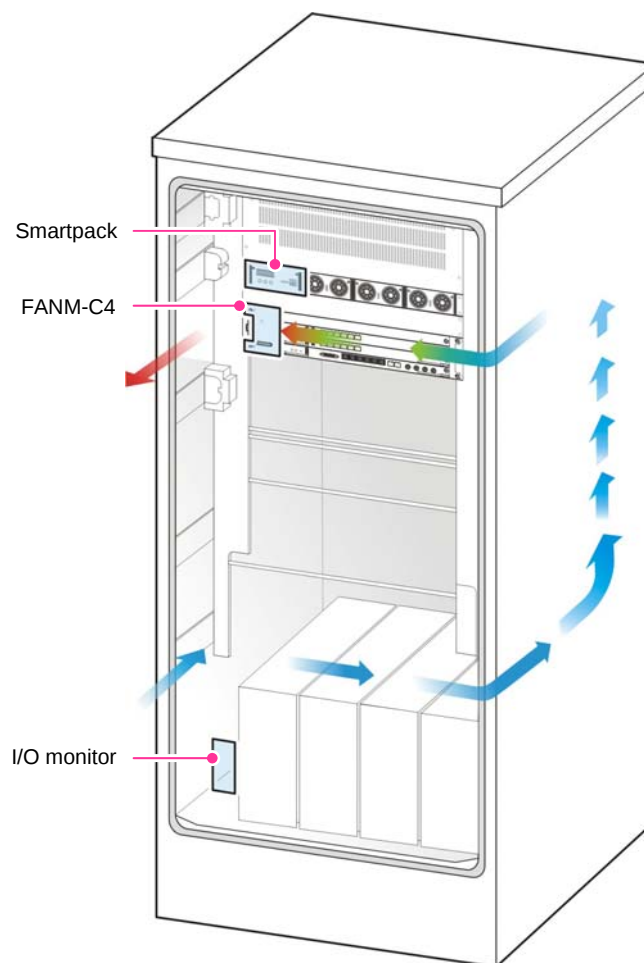


Figure 3.7 Outdoor eNB's Heat Discharge

The following table shows the outdoor eNB's environmental devices.

Name	Quantity	Function
FAN	2	- Outdoor rack's cooling fan - Controls the fan according to the system's internal temperature detected through the sensor installed in the rack • Room temperature mode: Low-speed operation • High temperature mode: High-speed operation.
FANM-C4	1	Fan Module-C4 UADU's cooling fan
SmartPack & I/O monitor	1	- The built-in sensor detects the system temperature. - Collects fire alarms - Collects 'door open' alarms - Collects flood alarms - Collects 'door fan' alarms - Reports collects alarms to the UAMA
Sensor	5	Sensors for temperature (2), flood (1), fire (1) and door (1)

UADU

A cooling fan is installed to keep the UADU shelf's internal temperature optimal. This allows the UADU to operate normally regardless of changes to the external temperature.

The UADU's heat-discharge mechanism is shown below.

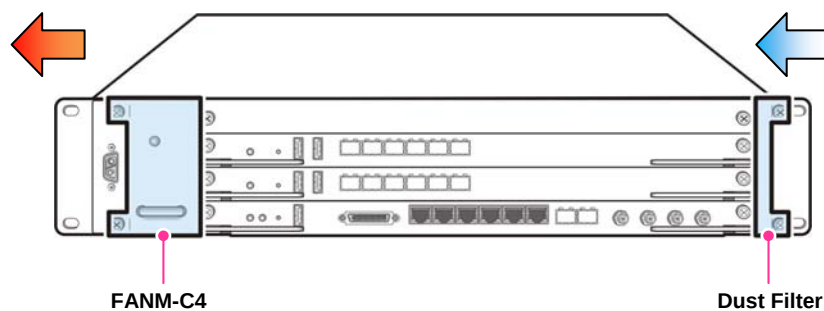


Figure 3.8 UADU Heat-Discharge Mechanism

L8HU

The L8HU is designed to discharge heat effectively through natural cooling without an additional cooling device.

The following shows the outdoor eNB's sensors.

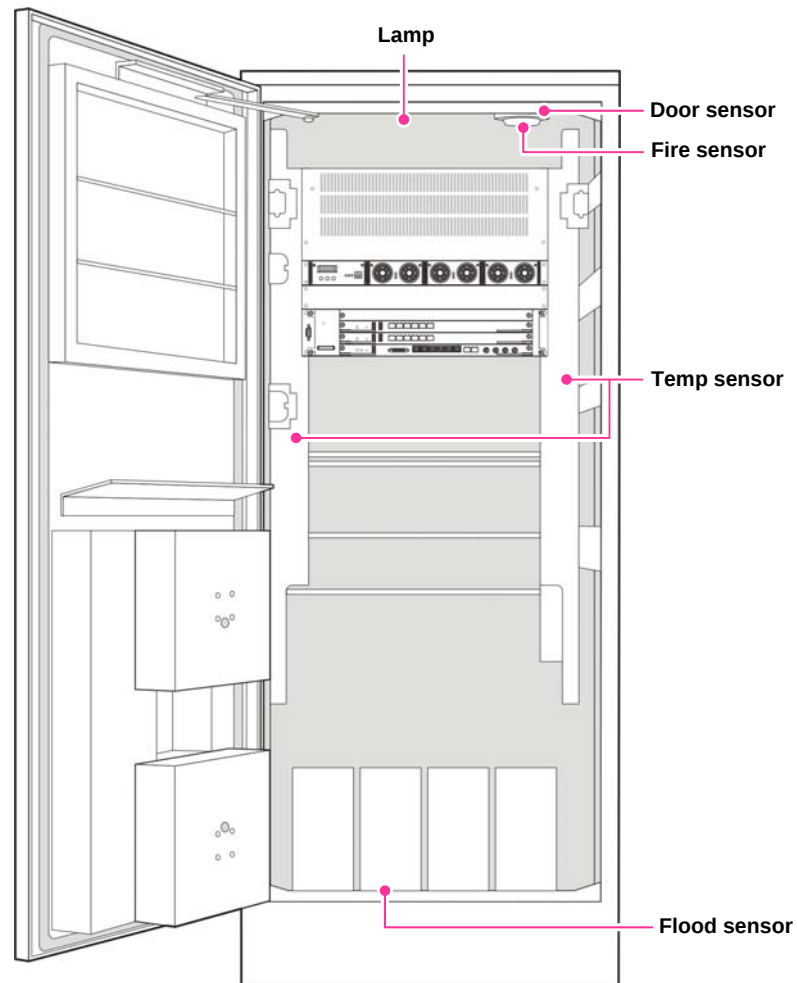


Figure 3.9 Sensors

The smartpack and I/O monitor maintain/control the outdoor rack's internal temperature, and collect/report external environment alarms.

The smartpack and I/O monitor detects the rack's internal temperature through the sensor in the air outlet of the UADU to control the FAN speed. They are connected to the environmental sensors (for temperature, flood, fire and door) installed in the rack to gather environment data real-time, and report environment alarms to the LSM at the UAMA.

3.1.5 External Interface

External Interfaces of UADU

The following shows the interfaces of UADU.

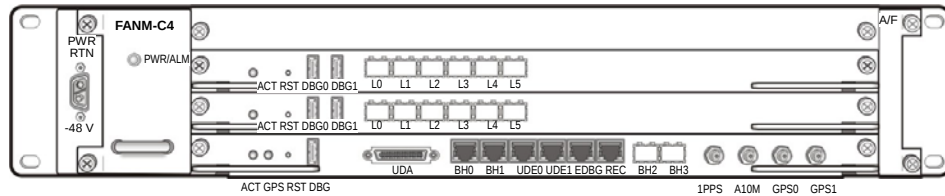


Figure 3.10 UADU External Interface

Unit	Interface	Description
PWR	RTN/-48 V	Power Input (RTN/-48 V)
FANM-C4	PWR/ALM	Fan Module-C4 UADU's cooling fan
UAMA	ACT	CPU Active LED
	GPS	UCCM Status LED
	RST	Reset Switch (CPU Chip Reset)
	DBG	For the debugger (UART, RS-232)
	UDA	User Defined Alarm (Rx: 9 port, Tx: 2 port), Mini Champ
	BH0, BH1	Copper Backhaul (1000Base-T), RJ-45
	UDE0, UDE1	User Defined Ethernet (1000Base-T), RJ-45
	EDBG	For the debugger (10/100/1000Base-T), RJ-45
	REC	For the rectifier, RS-485
	BH2, BH3	1000Base-LX or SX, RJ-45
	1PPS	Test Port 1PPS Output (from UCCM), SMA
	A10M	Test Port Analog 10 M Output (from UCCM), SMA
	GPS 0	GPS ANT Input #0 (to UCCM), SMA
	GPS 1	GPS ANT Input #1 (to UCCM), SMA
L9CA	ACT	L9CA ACT LED
	RST	System reset
	DBG0, DBG1	UART DSP Debug, USB
	L0~5	L8HU IF (CPRI 4.0), Optic
	EDBG	10/100/1000 Base-T, RJ-45
Dust filter	A/F	Dust filter

L8HU External Interface

The following shows the external interfaces of L8HU.

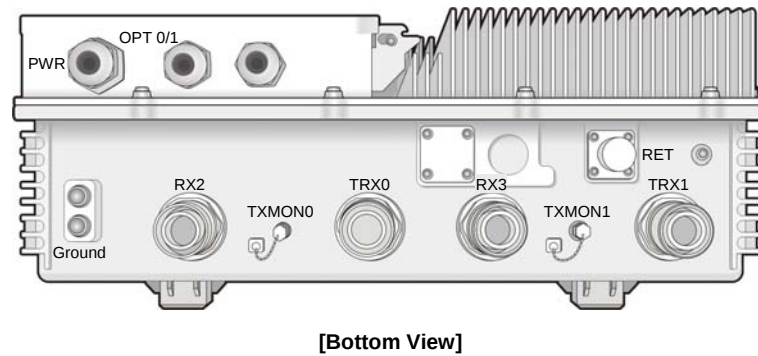


Figure 3.11 L8HU External Interface

Interface	Description
PWR	DC -48 V power input port
Ground	Frame Ground
OPT 0/1	Optic cable terminal connected to the UADU (cable gland)
RX2	RF receiving terminal #2
TXMON0	Tx signal monitoring terminal #0
TRX0	RF Tx/Rx terminal #0
RX3	RF receiving terminal #3
TXMON1	Tx signal monitoring terminal #1
TRX1	RF Tx/Rx terminal #1
RET	AISG connector for remote electric tilting

3.2 Software Architecture

3.2.1 Basic Software Architecture

The LTE eNB software is divided into three parts, kernel space (OS/DD), forwarding space (NPC and NP), and user space (MW, IPRS, CPS and OAM). Below is described each part.

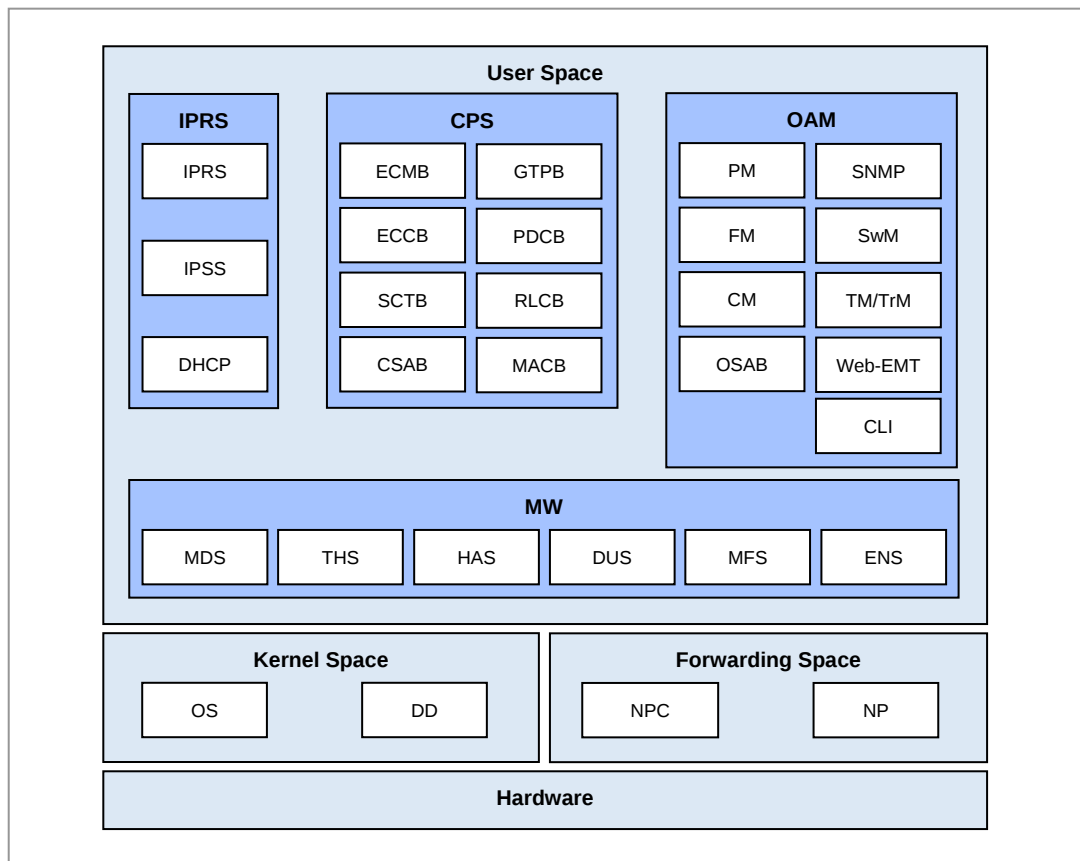


Figure 3.12 eNB Software Architecture

Operating System (OS)

The OS resets/controls hardware devices and allows the software on those devices to run. It consists of the booter, kernel, root file system (RFS) and utility.

- **Booter:** A module that 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 in accordance with the File-system Hierarchy Standard (FHS) 2.2.
- **Utility:** Provides the functions for managing the CPLD (Complex Programmable Logic Device), 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 device driver allows applications to operate normally on devices that are not directly controlled from the OS in the system. It consists of a 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 DD and Ethernet MAC driver, etc.)
- Virtual DD: Virtualizes the physical network interfaces in the kernel so that high-level applications control the virtual interfaces, rather than the physical network interfaces directly.

NPC (Network Processing Control)

The NPC creates/manages tables to process NP software packets and gathers/manages network statistics and statuses by interfacing with high-level processes such as IPRS and OAM.

Network Processing (NP)

The NP software processes packets necessary for backhaul interfacing. The NP has the following features.

- Packet RX and TX
- IPv4 and IPv6
- Packet queuing and scheduling
- 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).

- MDS: Provides all services related to message sending and receiving.
- DUS: Provides the function for transmitting debugging information and command between the applications and the operator.
- ENS: Registers and manages various events such as timers, and provides the function for sending an event message to the 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, the task control function, and the function for providing task information, etc.
- Miscellaneous Function Service (MFS): The MFL is responsible for all hardware-dependent functions, such as accessing physical addresses of hardware devices.

IP Routing Software (IPRS)

The IP routing software is responsible for IP routing and security for the eNB backhaul. The IPRS consists of IPRS, IPSS (IP Security Software), DHCP (Dynamic Host Configuration Protocol), each with the following features:

- IPRS: Collects and manages the system configuration and status information necessary for IP routing. Based on this data, the IPRS provides the function for creating routing information.
 - Ethernet, VLAN-TE, link aggregation management
 - Ethernet OAM
 - IP address management
 - IP routing information management
 - QoS management
- IPSS: Software to perform the security function for the IP layer. It performs the filtering function referring to IP address, TCP/UDP port number, and protocol type.
- DHCP: Software block to perform the automatic IP address allocation function. The DHCP provides the function for obtaining an IP address automatically by communicating with the DHCP server.

3.2.2 CPS Block

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

According to eNB specifications by the 3GPP, the ECS is composed of the SCTB, ECMB, ECCB, SCTB and CSAB. The EDS is composed of GTPB, PDCB, RLCB and MACB. The following shows the CPS architecture.

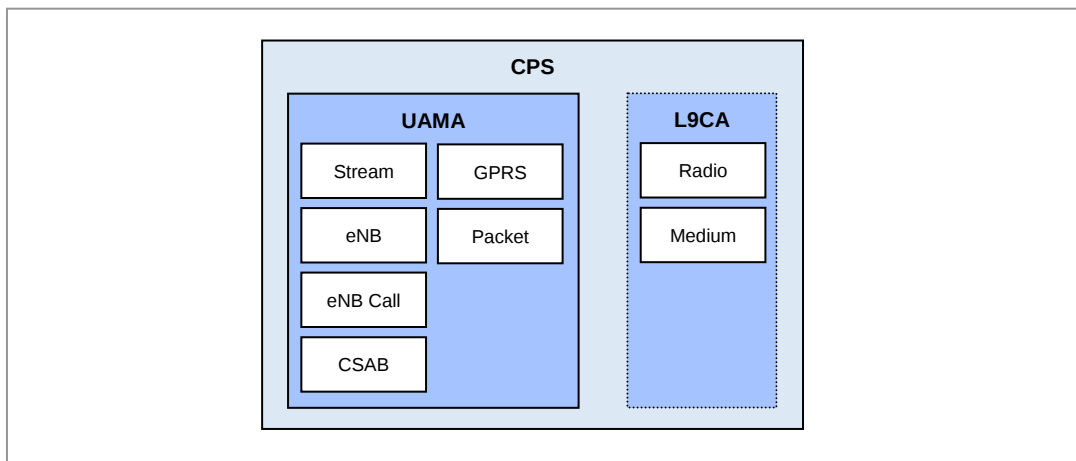


Figure 3.13 CPS Architecture

Stream Control Transmission protocol Block (SCTB)

The SCTB acts as the S1 interface between the eNB and the MME, and as the X2 interface with the adjacent eNBs. It runs on the UAMA.

The SCTB has the following major functions:

- S1 interfacing
- X2 interfacing

eNB Common Management Block (ECMB)

The ECMB is responsible for call processing per eNB/cell, such as transmitting system information and controlling the eNB overload. It runs on the UAMA.

The ECMB has the following major functions:

- Cell setting/release
- System information transmission
- eNB overload control
- Access barring control
- Resource measurement control
- Cell load information transmission

eNB Call Control Block (ECCB)

The ECCB is responsible for controlling a series of call processes between call setting and release as well as for processing calls from the MME and neighbor eNB. It runs on the UAMA.

The ECCB has the following major functions:

- Radio Resource Management
- Idle-Active status transition
- Bearer setting/change/release
- Paging
- MME selection and load balancing
- Call admission control
- Security
- Handover control
- UE measurement control
- Statistics processing
- SON-related call processing (mobility robustness and RACH optimization)

CPS SON Agent Block (CSAB)

The CSAB acts as a self-organizing network (SON) performed by the eNB CPS, and runs on the UAMA.

The CSAB has the following major functions:

- Mobility robustness optimization
- RACH optimization

GPRS Tunneling Protocol Block (GTPB)

The GTPB is responsible for GTP handling as part of call processing in the eNB user plane, and runs on the UAMA.

The GTPB has the following major functions:

- GTP tunnel control
- GTP management
- GTP data transmission

PDCP Block (PDCB)

The PDCB is responsible for PDCP handling as part of call processing in the eNB user plane, and runs on the UAMA.

The PDCB has the following major functions:

- Header compression/decompression: ROHC only
- User and control plane data transmission
- PDCP sequence number maintenance
- DL/UL data forwarding during handover
- User and control data ciphering/deciphering
- Control data integrity protection
- Timer based PDCP SDU discard

Radio Link Control Block (RLCB)

The RLCB is responsible for RLC protocol handling as part of call processing in the eNB user plane, and runs on the L9CA.

The RLCB has the following major functions:

- Higher-layer PDU transmission
- Automatic repeat request (ARQ) for 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 responsible for MAC protocol handling as part of call processing in the eNB user plane, and runs on the L9CA.

The MACB has the following major functions:

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

3.2.3 OAM Blocks

The operation and maintenance (OAM) block is responsible for eNB operations and maintenance.

The OAM consists of the OSAB, PM, FM, CM, SNMP, SwM, TM, TrM, Web-EMT and CLI. The OAM has the following major functions:

OSAB (OAM SON Agent Block)

- Self-configuration and self-establishment of system information
- Automatic neighbor relation (ANR) optimization
- Energy saving management

Performance management (PM)

- Statistics collection
- Statistics storage
- Statistics transmission

Fault management (FM)

- Fault detection and alarm reporting
- Alarm view
- Alarm filtering
- Alarm severity setting
- Alarm threshold setting
- Alarm correlation
- Status management and reporting
- Status view

Configuration management (CM)

- System/cell addition/removal
- Configuration view/change/add/remove
- Call parameter view/change
- Neighbor view/change/add/remove

SNMP (Simple Network Management Protocol)

Interface with the SNMP Manager

SwM (Software Management)

- Software and data file download/install
- Hardware unit and system reset
- Status monitoring of software units in operation
- Software and firmware information management/update
- Software upgrade
- Inventory management

Test management (TM)

- OCNS (Orthogonal Channel Noise Simulator) setting/release
- Model setting/release
- Ping test
- Tx/Rx output measurement
- Antenna VSWR (Voltage Standing Wave Ratio) measurement

Trace management (TrM)

Call trace

Web-EMT (Web-based Element Maintenance Terminal)

- Web server
- Operation with other OAM blocks for processing commands

Command Line Interface (CLI)

- CLI user management
- Command input and output display
- Fault/status message display

CHAPTER 4. Message Flows

4.1 Call-Processing Message Flows

This chapter describes message flow diagrams and functions for attach, service request, detach and handover processes. The handover process includes the intra E-UTRAN handover and inter-RAT (UTRAN) handover processes. The message flow diagram and function of the CS fallback process as part of the inter RAT (UTRAN, GERAN) operation are described below.

Attach Process

The figure below shows the message flow of the Attach procedure.

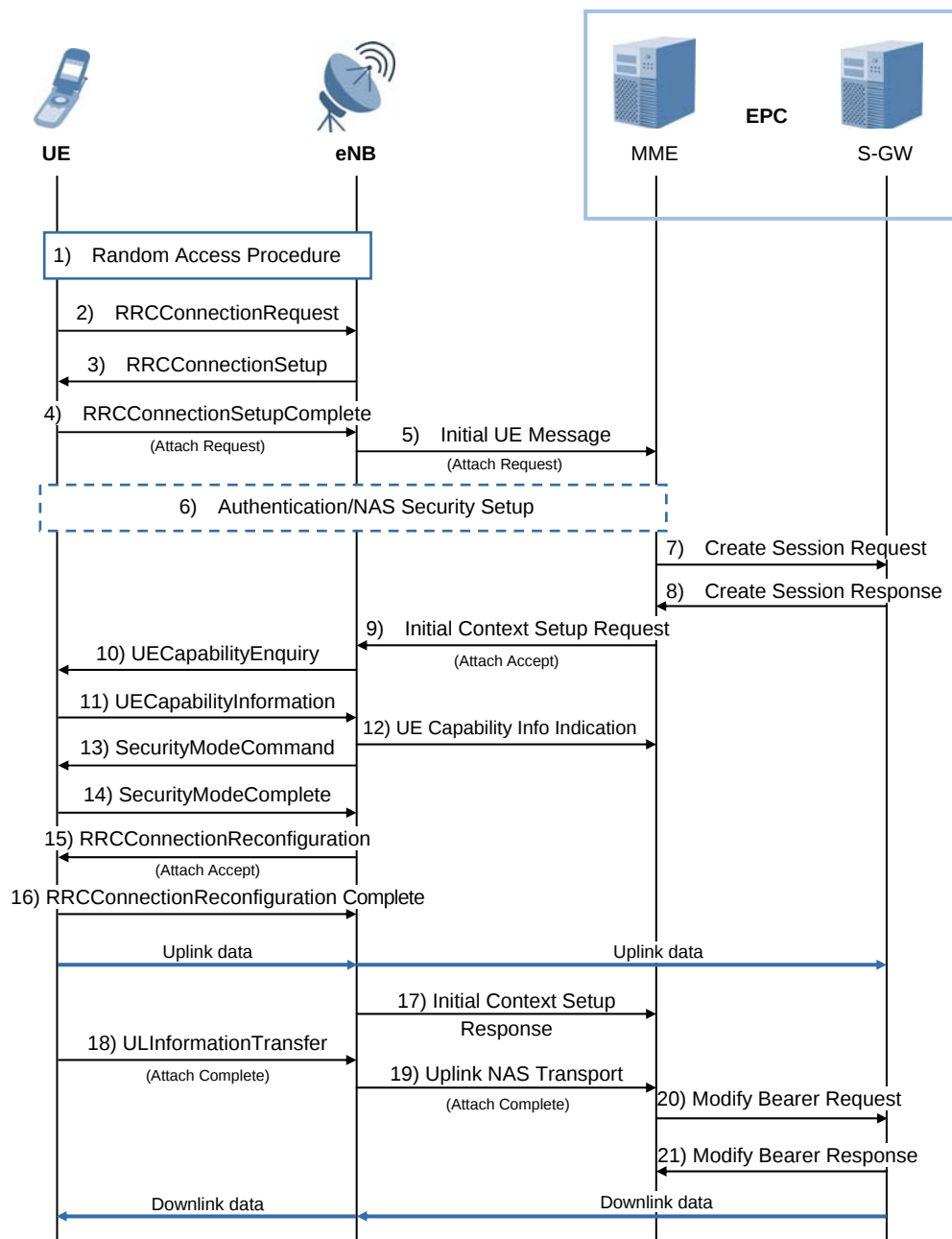


Figure 4.1 Attach Process

Step	Description
1	The UE runs the Random Access process (TS 36.321, 5.1) with the eNB.
2-4	The UE initializes the RRC Connection Establishment process (TS 36.331, 5.3.3). The UE includes the ATTACH REQUEST message (NAS) in the RRCConnectionSetupComplete message (PRC) and sends it to the eNB.
5	The eNB induces the MME from the RRC factors, includes the ATTCH REQUEST message in the INITIAL UE message, which is an S1-MME Control message, and sends it to the MME.
6	If there is no UE context in the network, the integrity of the ATTACH REQUEST message is not protected, or the integrity check fails, then authentication and NAS security setup are performed as a requisite. The UE runs the Evolved Packet System (EPS) Authentication and Key Agreement (AKA) process (TS 33.401, 6.1.1) with the MME. The MME establishes an NAS security association with the UE using the NAS Security Mode Command (SMC) process (TS 33.401, 7.2.4.4).
7-8	The MME selects the P-GW and S-GW. The MME sends the Create Session Request message to the S-GW. The S-GW adds an item to the EPS bearer table. From this step and until it receives the Modify Bearer Request message of Step 20, the S-GW stores the downlink packet received from the P-GW. The S-GW sends the Create Session Response message back to the MME.
9	The MME includes the ATTACH REQUEST message in the INITIAL CONTEXT SETUP REQUEST message, which is an S1-MME Control message, and sends it to the eNB. This S1 message also includes the AS security context information on the UE, which starts the RRC-level AS SMC process.
10-12	If the INITIAL CONTEXT SETUP REQUEST message doesn't have UE Radio Capability IE, the eNB starts the process to obtain UE Radio Capability from the UE, and sends the results to the MME.
13-14	The eNB sends the Security Mode Command message to the UE, and the UE responds with the SecurityModeComplete message. In the eNB, downlink encryption must start after Security Mode Command is transmitted and the uplink decryption must start after Security Mode Complete is received. In the UE, the uplink encryption must be started after the SecurityModeComplete message has been sent, and the downlink decryption must be started after the SecurityModeCommand message has been received (TS 33.401, 7.2.4.5).
15-16	The eNB includes ATTACH ACCEPT in the RRC Connection Reconfiguration message and sends it to the UE. The UE sends the RRC Connection Reconfiguration Complete message to the eNB. After receiving the ATTACH ACCEPT message, the UE can send uplink packets to the S-GW and P-GW via the eNB.
17	The eNB sends the INITIAL CONTEXT SETUP RESPONSE message to the MME.
18-19	The UE sends the UL Information Transfer message containing the ATTACH COMPLETE to the eNB. The eNB passes the UPLINK NAS TRANSPORT message containing the ATTCH COMPLETE to the MME.
20-21	After receiving both of the INITIAL CONTEXT RESPONSE message at step 17 and the ATTACH COMPLETE message at step 19, the MME sends the Modify Bearer Request message to the S-GW. The S-GW sends the Modify Bearer Response message to the MME, and then can send the stored downlink packets.

Service Request Initiated by the UE

The figure below shows the message flow of the Service Request procedure initiated by the UE.

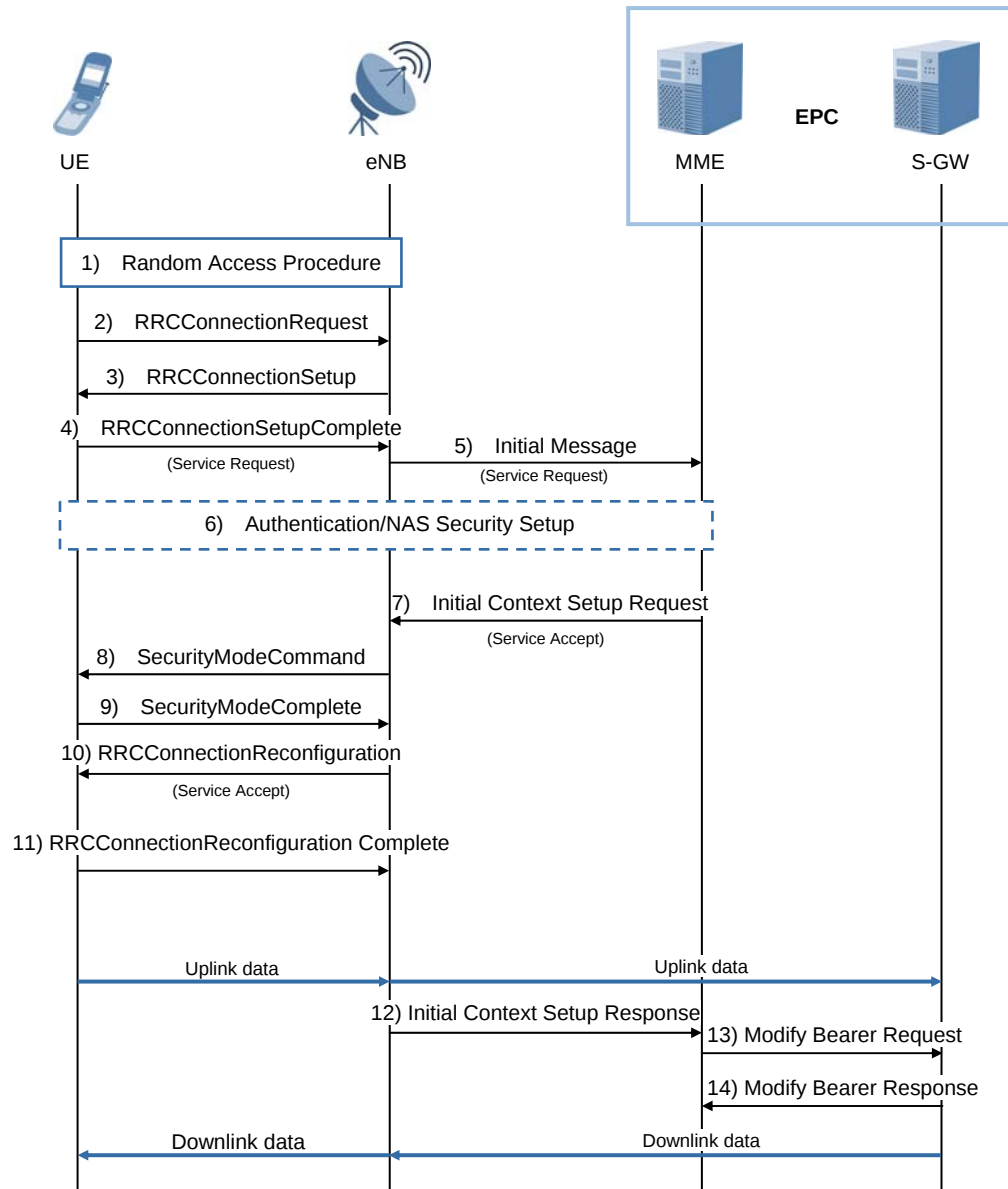


Figure 4.2 Service Request Process by UE

Step	Description
1	The UE runs the Random Access process with the eNB.
2-4	The UE includes the SERVICE REQUEST message, which is an NAS message, in the RRC message that will be sent to the eNB, and sends it to the MME.
5	The eNB includes the SERVICE REQUEST message in the INITIAL UE message, which is an S1-AP message, and passes it to the MME.
6	If there is no UE context for the UE in the network, the integrity is not protected for the ATTACH REQUEST message, or the integrity check fails, an authentication and an NAS security setup are always performed. The UE carries out the EPS AKA procedure (TS 33.401, 6.1.1) with the MME. The MME establishes an NAS security association with the UE using the NAS SMC process (TS 33.401, 7.2.4.4).
7	The MME sends the INITIAL CONTEXT SETUP REQUEST message, which is an S1-AP message, to the eNB. This step activates radio and S1 bearers for all active EPS bearers.
8-11	The eNB sets up the RRC radio bearers. The user plane security is established at this step. The uplink data from the UE can now be passed by the eNB to the S-GW. The eNB sends the uplink data to the S-GW, which, in turn, passes it to the P-GW.
12	The eNB sends the INITIAL CONTEXT SETUP RESPONSE message, which is an S1-AP message, to the MME.
13-14	The MME sends the Modify Bearer Request message per PDN connection to the S-GW. The S-GW can now send the downlink data to the UE, and sends Modify Bearer Response to the MME.

Service Request by Networking

The message flow diagram below shows the Service Request process by networking.

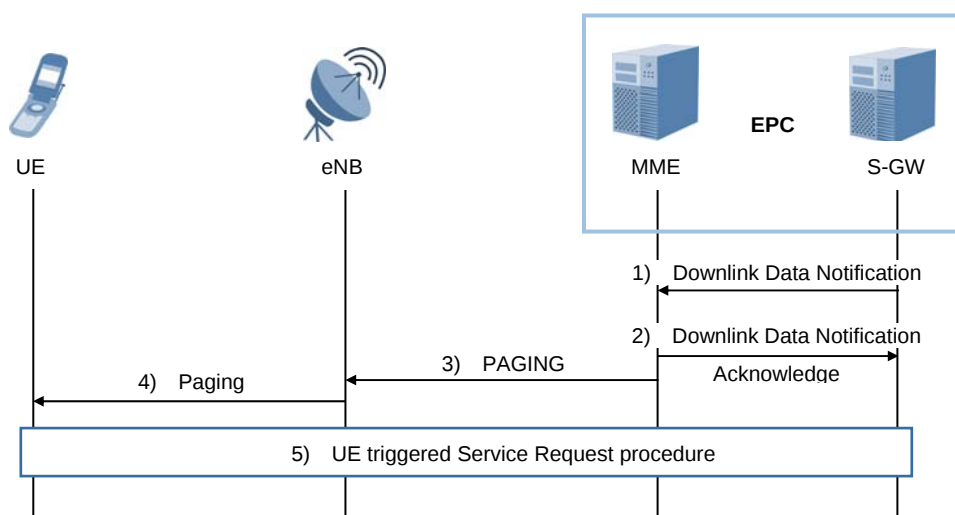


Figure 4.3 Service Request Process by Networking

Step	Description
1-2	When the S-GW receives downlink data packets for a UE whose user plane is not connected, it sends the Downlink Data Notification message to the MME which has the control plane connection with the UE. The MME replies to the S-GW with the Downlink Data Notification Acknowledge message. The S-GW stores additional downlink data packets for the UE when it receives them. In this case, it does not send a new Downlink Data Notification message.
3-4	When the UE is registered to the MME, the MME sends the PAGING message to all eNBs that belong to the trace area where the UE is registered. When the eNB receives the PAGING message from the MME, the eNB sends the Paging message to the UE.
5	When the UE in Idle mode receives the PAGING message via the E-UTRAN connection, the Service Request procedure initiated by the UE is started. The S-GW sends the downlink data to the UE via the RAT which has performed the Service Request procedure.

Detach Initiated by the UE

The figure below shows the message flow of the Detach procedure initiated by the UE.

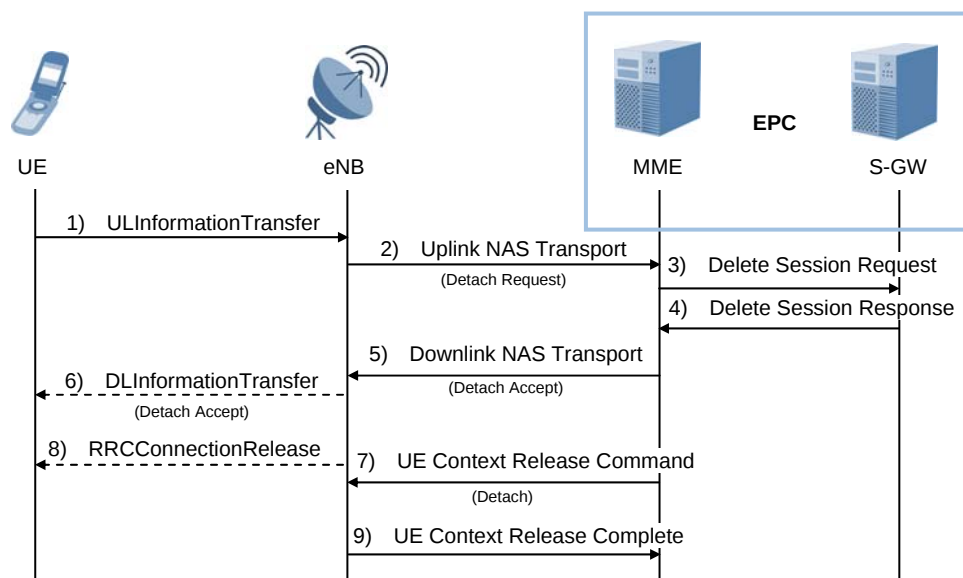


Figure 4.4 Detach Process by UE

Step	Description
1-2	The UE sends the DETACH REQUEST message, which is an NAS message, to the MME. This NAS message is used to start setting up an S1 connection when the UE is in Idle mode.
3	The active EPS bearers and their context information for the UE and MME which are in the S-GW are deactivated when the MME sends the Delete Session Request message for each PDN connection.
4	When receiving the Delete Session Request message from the MME, the S-GW releases the related EPS bearer context information and replies with the Delete Session Response message.
5-6	If the detach procedure has been triggered due to other reason except for the case that the power of the UE was turned off, the MME sends the DETACH ACCEPT message to the UE.
7	The MME sets the Cause IE value of the UE CONTEXT RELEASE COMMAND message to 'Detach' and sends this message to the eNB to release the S1-MME signaling connection to the UE.
8	If the RRC connection has not yet been released, the eNB sends the RRCConnectionRelease message to the UE in Requested Reply mode. Once a reply to this message is received from the UE, the eNB removes the UE context.
9	The eNB returns the UE CONTEXT RELEASE COMPLETE message to the MME to confirm the S1 release. This releases the signaling connection between the MME and ENB for the UE. This step must be performed immediately following step 7.

Detach Initiated by the MME

The figure below shows the message flow of the Detach procedure initiated by the MME.

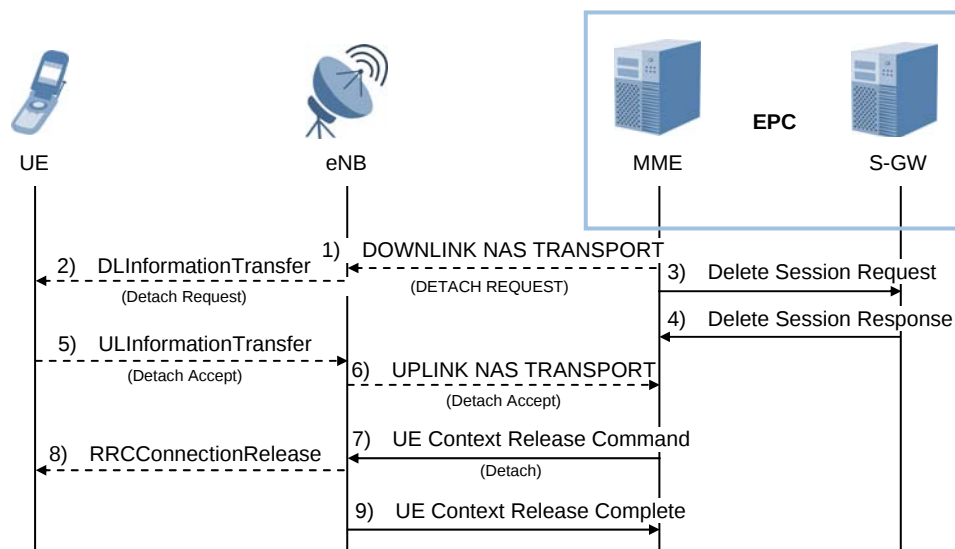


Figure 4.5 Detach Process by MME

Step	Description
1-2	The MME detaches the UE implicitly if there is no communication between them for a long time. In case of the implicit detach, the MME does not send the DETACH REQUEST message to the UE. If the UE is in the connected status, the MME sends the DETACH REQUEST message to the UE to detach it explicitly.
3-4	These steps are the same as Step 3 and 4 in 'Detach Procedure by UE'.
5-6	When the UE receives the DETACH REQUEST message from the MME in Step2, the UE sends the DETACH ACCEPT message to the MME. The eNB transmits this NAS message to the MME.
7	After receiving both of the DETACH ACCEPT message and the Delete Session Response message, the MME sets the Cause IE value of the UE CONTEXT RELEASE COMMAND message to 'Detach' and sends this message to the eNB to release the S1 connection to the UE.
8-9	These steps are the same as Step 8 and 9 in 'Detach Procedure by UE'.

LTE Handover-X2-based Handover

The figure below shows the message flow of the X2-based Handover procedure.

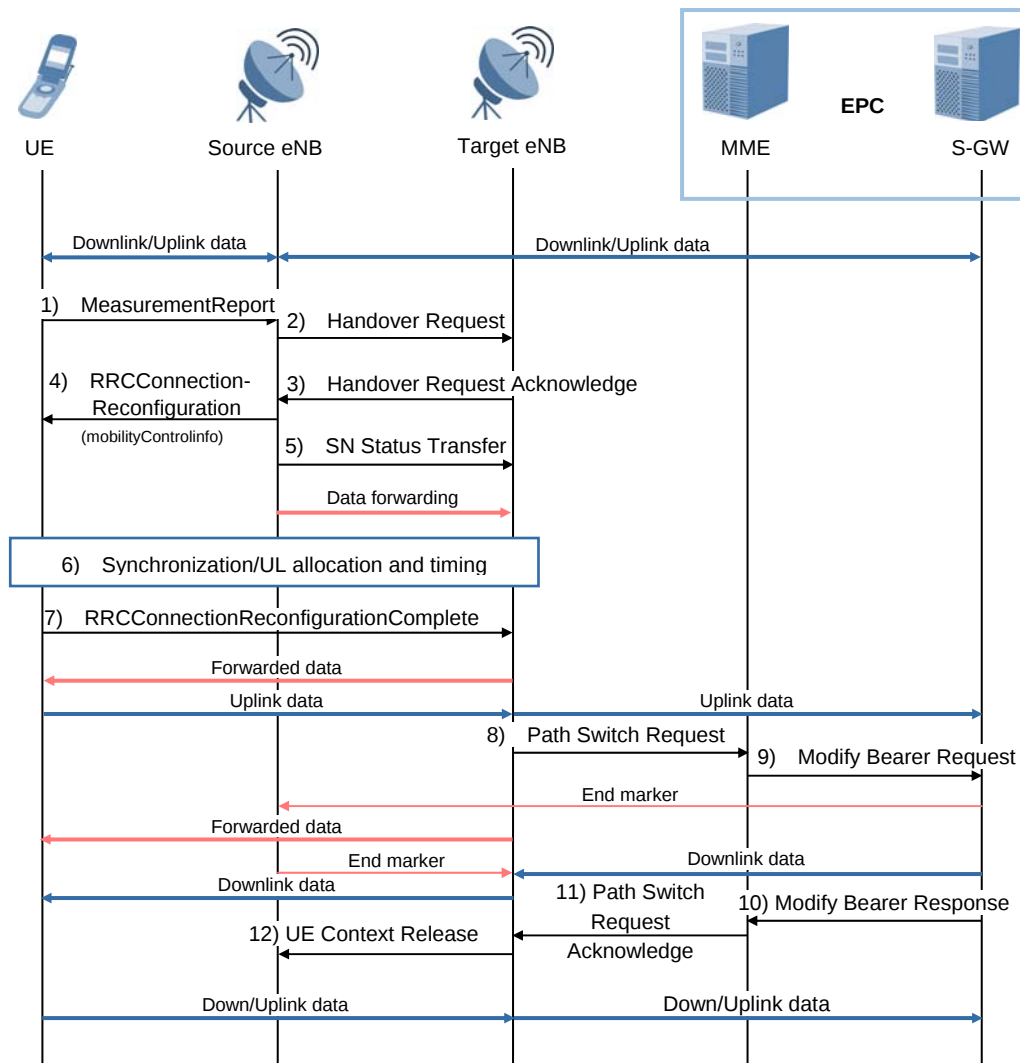


Figure 4.6 X2-based Handover Process

Step	Description
1	The UE sends the Measurement Report message according to the system information, standards and rules. The UE sends the Measurement Report message according to the system information, standards and rules.
2	The source eNB sends the target eNB a HANDOVER REQUEST message containing the information required for handover. The target eNB can perform management control in accordance with the received E-RAB QoS information.
3-4	The target eNB prepares the handover and creates an RRCConnectionReconfiguration message, containing the mobileControlInfo IE that tells the source eNB to perform the handover. The target eNB includes the RRCConnectionReconfiguration message in the HANDOVER REQUEST ACKNOWLEDGE message, and sends it to the source eNB. The source eNB sends the UE an RRCConnectionReconfiguration message, containing the needed parameter values to command it to perform the handover.
5	To send the uplink PDCP SN receiver status and the downlink PDCP SN transmitter status of the E-RABs of which the PDCP status must be preserved, the source eNB sends the SN STATUS TRANSFER message to the target eNB.
6	After receiving the RRCConnectionReconfiguration message containing mobileControlInfo IE, the UE performs synchronization with the target eNB and connects to the target cell via a Random Access Channel (RACH). The target eNB replies with an allocated UL and a timing advance value.
7	After having connected to the target cell successfully, the UE notifies the target eNB that the Handover procedure has been completed using an RRCConnection-ReconfigurationComplete message.
8	The target eNB, using the PATH SWITCH REQUEST message, notifies the MME that the UE has changed the cell.
9-10	The MME sends the Modify Bearer Request message to the S-GW. The S-GW changes the downlink data path into the target eNB. The S-GW sends at least one 'end marker' to the source eNB through the previous path, and releases the user plane resources for the source eNB. The S-GW sends a Modify Bearer Response message to the MME.
11	The MME sends the PATH SWITCH REQUEST ACKNOWLEDGE message to acknowledge the PATH SWITCH REQUEST message.
12	The target eNB sends the UE CONTEXT RELEASE message to the source eNB to notify the handover has succeeded and to make the source eNB release its resources. When receiving the UE CONTEXT RELEASE messages, the source eNB released the radio resource and the control plane resource related to the UE context.

LTE Handover-S1-based Handover

The figure below shows the message flow of the S1-based Handover procedure.

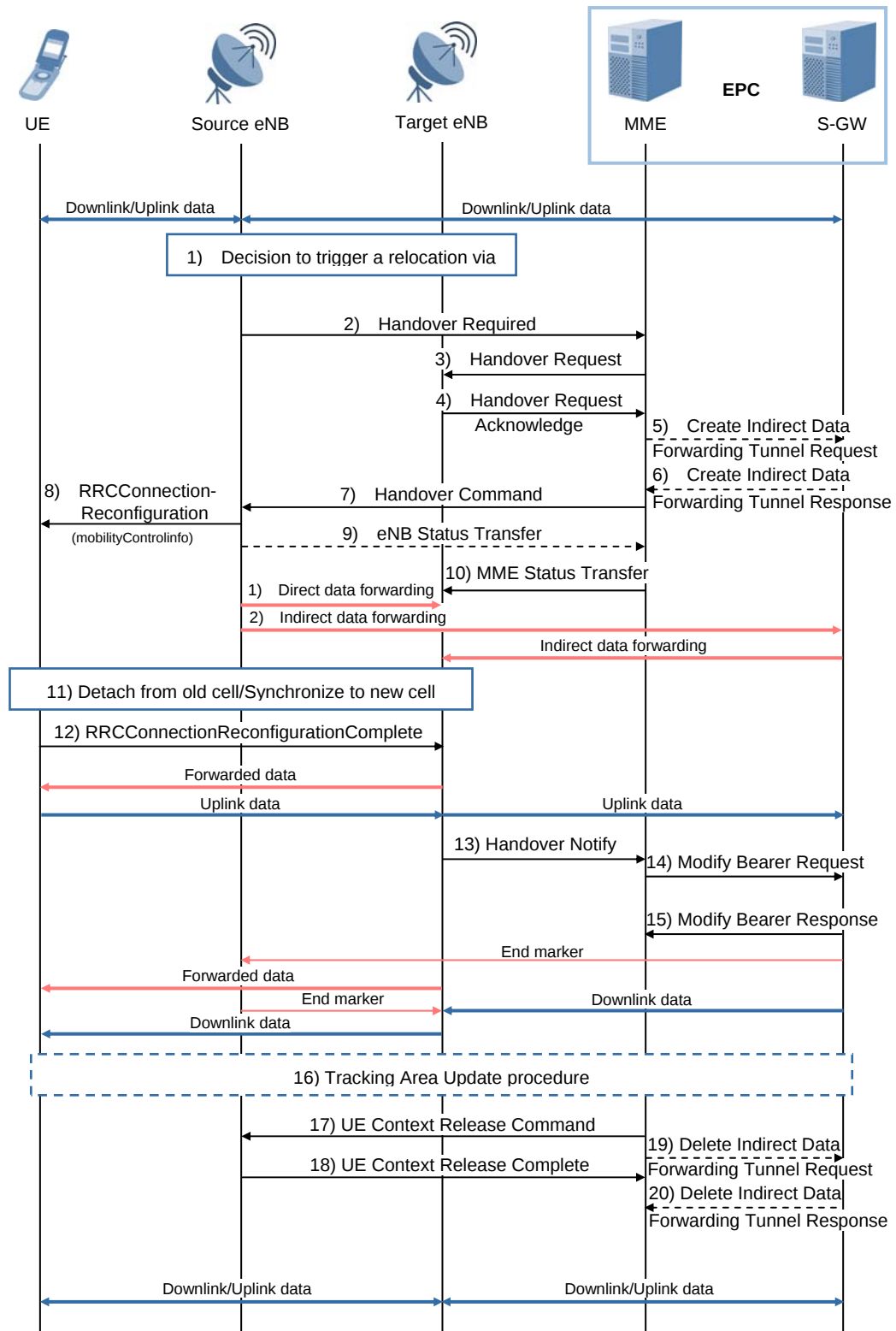


Figure 4.7 S1-based Handover Process

Step	Description
1	The source eNB determines whether to perform S1-based handover into the target eNB. The source eNB can make this decision when there is no X2 connection to the target or when an error is notified by the target eNB after an X2-based handover has failed, or based on the information the source eNB has obtained dynamically.
2	The source eNB sends the HANDOVER REQUIRED message to the MME. The source eNB notifies the target eNB which bearer is used for data forwarding and whether forwarding can be made directly from the source eNB to the target eNB.
3-4	The MME sends the HANDOVER REQUEST message to the target eNB. This message makes the target eNB to create a UE context containing the bearer-related information and the security context. The target eNB sends the HANDOVER REQUEST ACKNOWLEDGE message to the MME.
5-6	If indirect forwarding is used, the MME sends the Create Indirect Data Forwarding Tunnel Request message to the S-GW. The S-GW replies the MME with the Create Indirect Data Forwarding Tunnel Response message.
7-8	The MME sends the HANDOVER COMMAND message to the source eNB. The source eNB creates the RRCConnectionReconfiguration message using the Target to Source Transparent Container IE value contained in the HANDOVER COMMAND message and then sends it to the UE.
9-10	To send the PDCP status, and the HFN status of the E-RABs of which the PDCP status must be preserved, the source eNB sends the eNB/MME STATUS TRANSFER message to the target eNB via the MME. The source eNB must start forwarding the downlink data to the target eNB through the bearer which was determined to be used for data forwarding. This can be either direct or indirect forwarding.
11	The UE performs synchronization with the target eNB and connects to the target cell via a RACH. The target eNB replies with an allocated UL and a timing advance value.
12	After having synchronized with the target cell, the UE notifies the target eNB that the Handover procedure has been completed using the RRCConnectionReconfigurationComplete message. The downlink packets forwarded from the source eNB can be sent to the UE. The uplink packets can be also sent from the UE to the S-GW via the target eNB.
13	The target eNB sends the HANDOVER NOTIFY message to the MME. The MME starts the timer which tells when the resources of the source eNB and the temporary resources used by the S-GW for indirect forwarding will be released.
14	For each PDN connection, the MME sends the Modify Bearer Request message to the S-GW. Downlink packets are sent from the S-GW to the target eNB immediately.
15	The S-GW sends the Modify Bearer Response message to the MME. As soon as the target eNB changes the path to help packet reordering, the S-GW sends at least one 'end marker' packet to the source eNB through the previous path.
16	If any of the conditions listed in section 5.3.3.0 of TS 23.401 (6) are met, the UE starts the Tracking Area Update procedure.

(Continued)

Step	Description
17-18	When the timer started at step 13 expires, the MME sends the UE CONTEXT RELEASE COMMAND message to the source eNB. The source eNB releases the resources related to the UE and replies to the target eNB with the UE CONTEXT RELEASE COMPLETE message.
19-20	If indirect forwarding has been used, when the timer started at step 13 expires the MME sends the Delete Indirect Data Forwarding Tunnel Request message to the S-GW. This message gets the S-GW to release the temporary resources allocated for indirect forwarding at step 5. The S-GW replies to the MME with the Delete Indirect Data Forwarding Tunnel Response message.

Inter-RAT Handover-LTE to UTRAN PS Handover

Below is the message flow for the PS handover procedure from the E-UTRAN to the UTRAN.

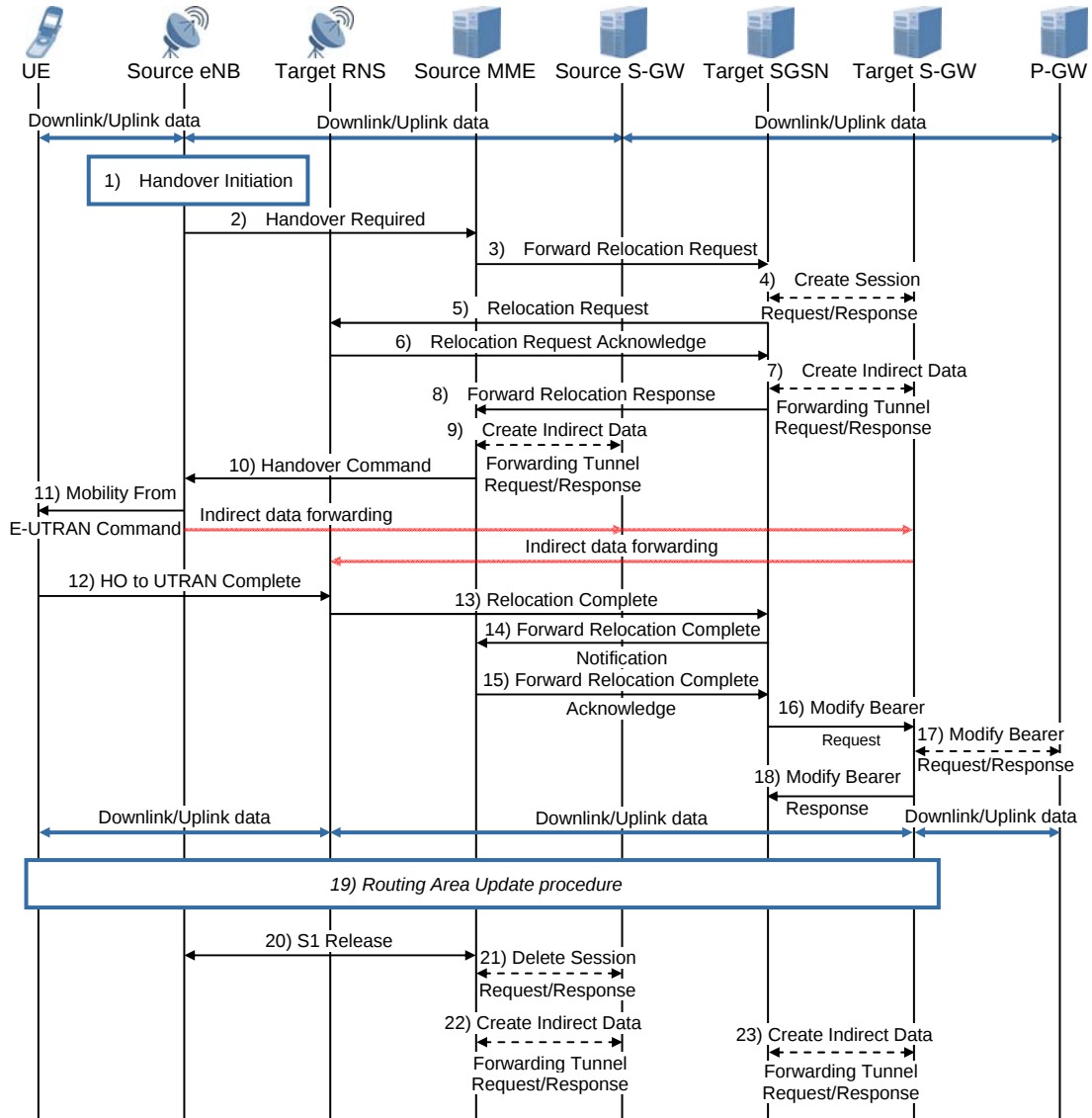


Figure 4.8 E-UTRAN-UTRAN PS Handover Process

Step	Description
1	The source eNB determines the PS handover to the UTRAN. This handover can be determined in accordance with the measurement report received from UE.
2	The source eNB sends the HANDOVER REQUIRED message to the MME. The source eNB then puts the Source RNC to Target RNC Transparent Container IE information into the message to transmit the information to the target RNC.

(Continued)

Step	Description
3-4	The source MME recognizes the handover from the target ID IE of the HANDOVER REQUIRED message to the UTRAN and sends the FORWARD RELOCATION REQUEST message to the target SGSN. The target SGSN determines whether to change the S-GW. Then if change is required, it carries out the Create Session Request/Response procedure with a new S-GW.
5-6	The target SGSN transmits the RELOCATION REQUEST message to the target RNC to request resource allocation for the target RNC. The target RNC carries out the CAC and resource allocation for each RAB for which handover is requested, and transmits the RELOCATION REQUEST ACKNOWLEDGE message containing the result to the target SGSN to respond to the request. The Target RNC to Source RNC Transparent Container IE to transmit to the source eNB is then contained.
7-9	To perform the forwarding tunnel setup, the target SGSN carries out the Create Indirect Data Forwarding Tunnel Request/Response procedure with target S-GW and transmits the FORWARD RELOCATION RESPONSE message to the source MME. To perform the forwarding tunnel setup, the source MME carries out the Create Indirect Data Forwarding Tunnel Request/Response procedure with the source S-GW.
10-11	The source MME sends the HANDOVER COMMAND message to the source eNB. By doing so, the handover preparation procedure to the target UTRAN is completed. The Source eNB configures the MOBILITY FROM E-UTRAN COMMAND containing the Target RNC to Source RNC Transparent Container IE in the HANDOVER COMMAND message and transmits it to the UE to request the PS handover to the UTRAN.
12	The UE performs synchronization with the target UTRAN and connects to the target cell via a RACH. After UE is successfully connected to the target cell, UE transmits the HANDOVER TO UTRAN COMPLETE message to the target UTRAN to complete the handover procedure.
13-15	The target RNC transmits the RELOCATION COMPLETE message to the target SGSN to notify that the handover procedure from the UE to the UTRAN has been completed successfully. The target SGSN transmits the FORWARD RELOCATION COMPLETE NOTIFICATION message to the source MME. At this time, the source MME operates the waiting timer for releasing the resource of the E-UTRAN and transmits the FORWARD RELOCATION COMPLETE ACKNOWLEDGE response message to the target SGSN. The target SGSN operates the waiting timer for releasing the forwarding tunnel at the time when the source MME receives the response message.
16-18	For each PDN connection, the target SGSN sends the Modify Bearer Request message to the target S-GW. The downlink packet is then transmitted from the S-GW to the target RNC. The target S-GW carries out the Modify Bearer Request/Response procedure with the P-GW and transmits the Modify Bearer Response message to the target SGSN.
19	When UE satisfies the conditions specified in section 5.5.2.1 of TS 23.401, the Routing Area Update procedure starts.
20-23	When the timer of procedure 14 has expired, the source MME requests the resource release procedure to be carried out on the source eNB and the source S-GW. When the timer of procedure 15 has expired, the target SGSN carries out the resource release allocated for the forwarding tunnel with the target S-GW.

Inter-RAT Handover-UTRAN to LTE PS Handover

Below is the message flow for the PS handover procedure from the UTRAN to the E-UTRAN.

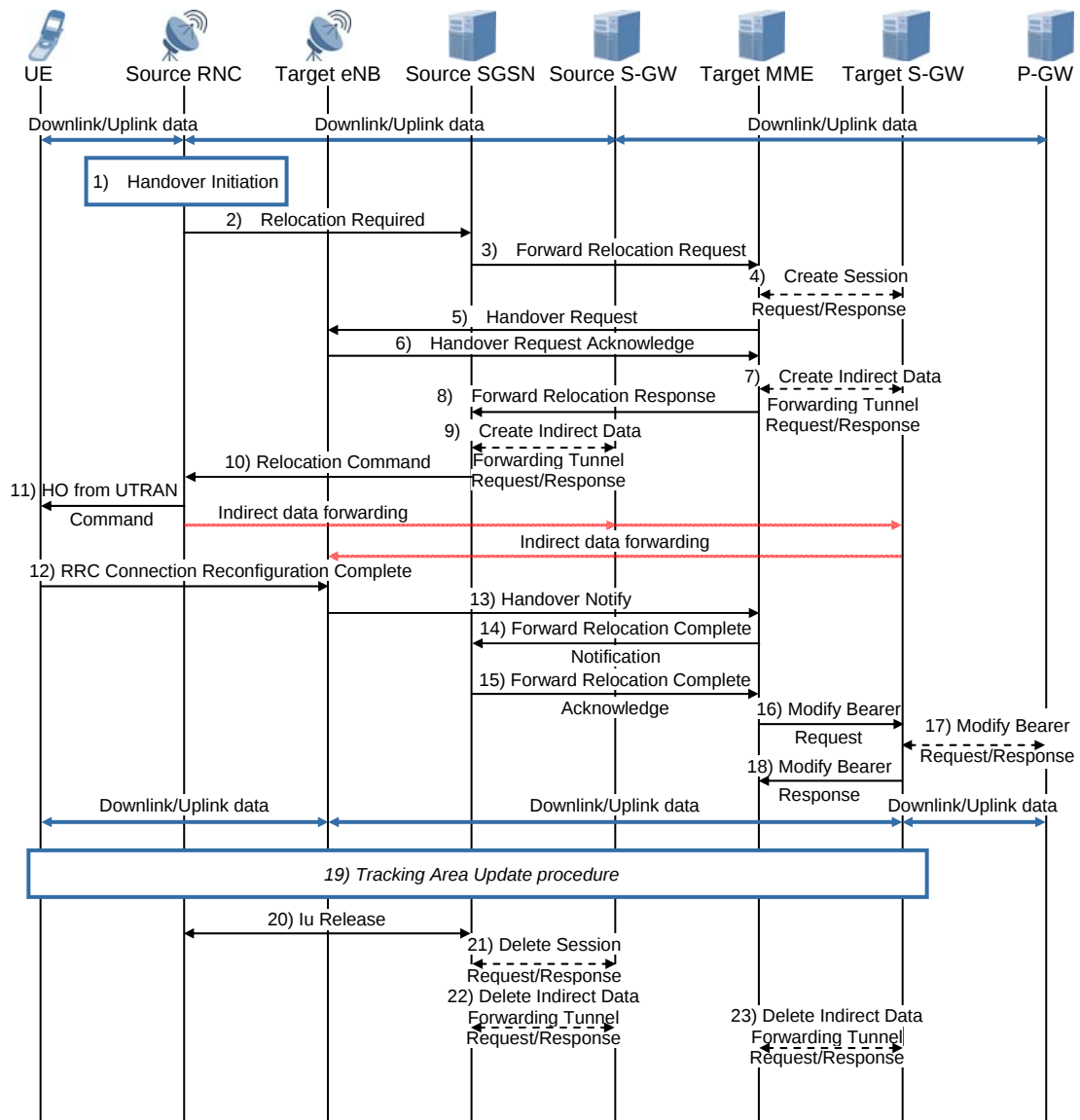


Figure 4.9 UTRAN-E-UTRAN PS Handover Process

Step	Description
1	The source RNC determines the PS handover to the E-UTRAN. This handover can be determined in accordance with the measurement report received from UE.
2	The source RNC sends the RELOCATION REQUIRED message to the SGSN. The source RNC then puts the Source eNB to Target eNB Transparent Container IE information into the message to transmit the information to the target eNB.

(Continued)

Step	Description
3-4	The source SGSN recognizes the handover from the target ID IE of the RELOCATION REQUIRED message to the E-UTRAN and sends the FORWARD RELOCATION REQUEST message to the target MME. The target MME determines whether to change the S-GW, if change is required, it carries out the Create Session Request/Response procedure with a new S-GW.
5-6	The target MME transmits the HANDOVER REQUEST message to the target eNB to request resource allocation for the target eNB. The target eNB carries out the CAC and resource allocation for each RAB for which handover is requested, and transmits the HANDOVER REQUEST ACKNOWLEDGE message containing the result to the target MME to respond to the request. At this time, the Target eNB to Source eNB Transparent Container IE to transmit to the source RNC is contained.
7-9	To perform the forwarding tunnel setup, the target MME carries out the Create Indirect Data Forwarding Tunnel Request/Response procedure with target S-GW and transmits the FORWARD RELOCATION RESPONSE message to the source SGSN. To perform the forwarding tunnel setup, the source SGSN carries out the Create Indirect Data Forwarding Tunnel Request/Response procedure with the source S-GW.
10-11	The source SGSN sends the RELOCATION COMMAND message to the source RNC. By doing so, the handover preparation procedure to the target E-UTRAN is completed. The source RNC configures the Handover FROM UTRAN COMMAND message containing the Target eNB to Source eNB Transparent Container IE in the RELOCATION COMMAND message and transmits it to UE to request the PS handover to the E-UTRAN.
12	The UE performs synchronization with the target E-UTRAN and connects to the target cell via a RACH. After UE is successfully connected to the target cell, UE transmits the RRC CONNECTION RECONFIGURATION COMPLETE message to the target E-UTRAN to complete the handover procedure.
13-15	The target eNB then transmits the HANDOVER NOTIFY message to the target MME to notify that the handover procedure to the E-UTRAN has been completed successfully. The target MME transmits the FORWARD RELOCATION COMPLETE NOTIFICATION message to the source SGSN. At this time, the source SGSN operates the waiting timer for releasing the resource of the UTRAN and transmits the FORWARD RELOCATION COMPLETE ACKNOWLEDGE response message to the target MME. The target MME operates the waiting timer for releasing the forwarding tunnel at the time when the source SGSN receives the response message.
16-18	For each PDN connection, the target MME sends the Modify Bearer Request message to the target S-GW. The downlink packet is then transmitted from the S-GW to the target eNB. The target S-GW carries out the Modify Bearer Request/Response procedure with the P-GW and transmits the Modify Bearer Response message to the target MME.
19	When UE satisfies the conditions specified in section 5.5.2.2 of TS 23.401, the Tracking Area Update procedure starts.
20-23	When the timer of procedure 14 has expired, the source SGSN requests the resource release procedure to be carried out on the source RNC and the source S-GW. When the timer of procedure 15 has expired, the target MME carries out the resource release allocated for the forwarding tunnel with the target S-GW.

CS Fallback to UTRAN

Below is the message flow for the CS Fallback process from the E-UTRAN to the UTRAN. The procedure below shows that the CS Fallback process is carried out through redirection processing to the UTRAN without PS HO when UE, which is in RRC Connected status, sends the CS call.

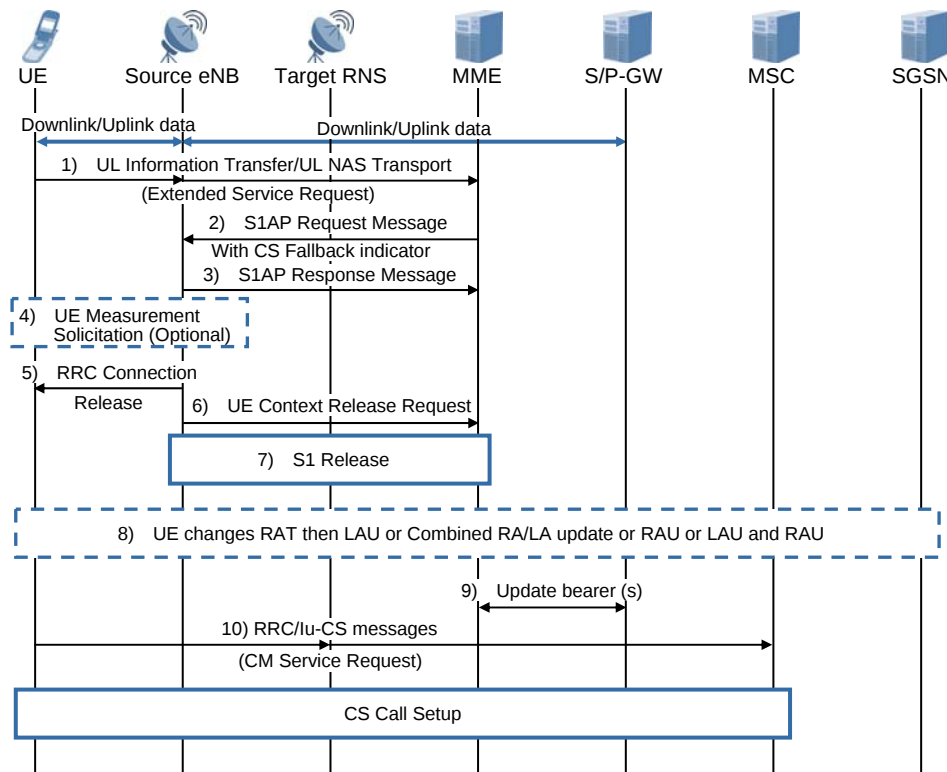


Figure 4.10 CS Fallback to UTRAN Process (UE in Active Mode, No PS HO Support)

Step	Description
1	When an RRC Connected UE in the E-UTRAN requests a CS call, it creates an EXTENDED SERVICE REQUEST message (NAS) containing the CS fallback indicator, and sends it to the network. The UE uses an RRC UL INFORMATION TRANSFER message. The eNB sends this to the MME using a UL NAS TRANSPORT message.
2-3	The MME prepares an S1AP message (UE CONTEXT MODIFICATION REQUEST) containing the CS fallback indicator, and sends it to the eNB to request CS fallback handling. The eNB transmits a response message (UE CONTEXT MODIFICATION RESPONSE) appropriate for Process 2 to the MME.
4	The eNB can instruct the UE to measure the target RAT if it needs the UE's measurement for CS fallback handling (optional).
5	The eNB uses a redirection process for a CS fallback to UTRAN. The eNB includes redirected carrier information on the target UTRAN in the RRC CONNECTION RELEASE message to send to the UE. The UE redirects to the UTRAN based on the redirected carrier information instructed by the eNB.
6	The eNB transmits the UE CONTEXT RELEASE REQUEST message to the MME.
7	The MME carries out the procedure for releasing the UE context of the E-UTRAN.

(Continued)

Step	Description
8	After connecting to the UTRAN, UE transmits the RRC INITIAL DIRECT TRANSFER message to set the CS signaling connection. If the LA or RA of the connected UTRAN cell is different from the stored information, the location registration procedure (LAU and/or RAU or combined LAU/RAU) is carried out.
9	After receiving the UE CONTEXT RELEASE REQUEST message in Procedure 6, the MME carries out the suspension processing of the non-GBR bearer (s) of the S-GW/P-GW and the deactivation processing of the GBR bearer (s). Afterward, the MME manages the UE context in the suspended status.
10	The UE transmits the CM SERVICE REQUEST message to the UTRAN to carry out next procedure for the CS call setup.

CS Fallback to GERAN

Below is the message flow for the CS Fallback procedure from the E-UTRAN to the GERAN. The procedure below shows that the CS Fallback procedure is carried out through Cell Change Order processing to the GERAN without PS HO when a UE which is in the RRC_Connected status sends the CS call.

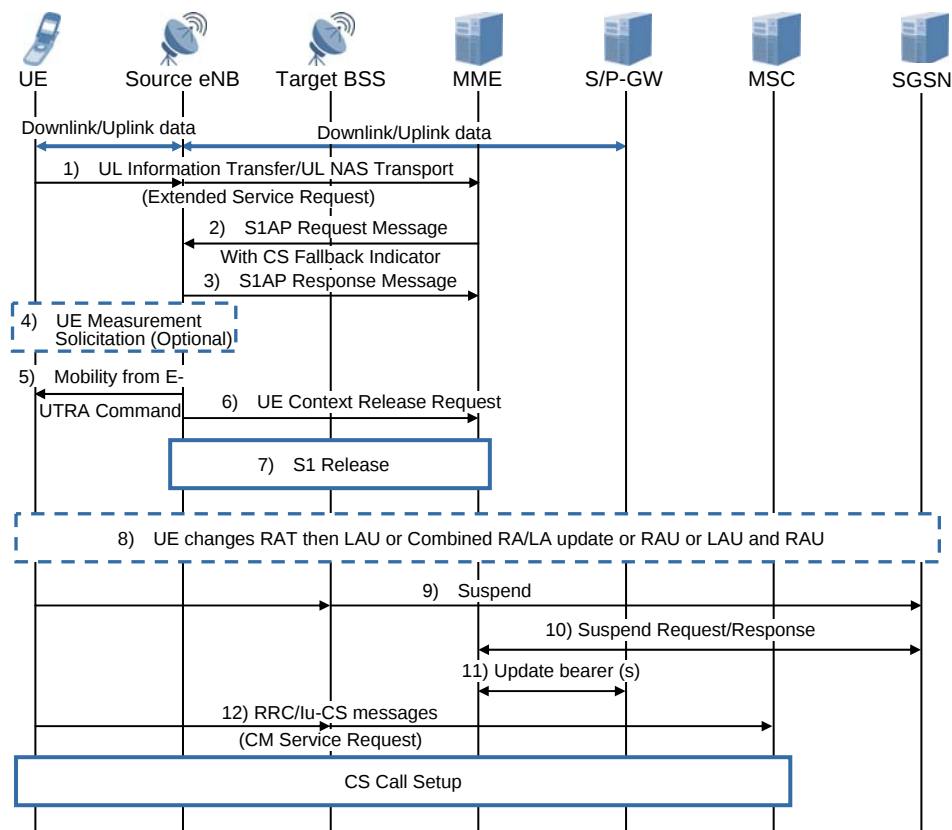


Figure 4.11 CS Fallback to GERAN Process (UE in Active Mode, No PS HO Support)

Step	Description
1	When an RRC Connected UE in the E-UTRAN requests a CS call, it creates an EXTENDED SERVICE REQUEST message (NAS) containing the CS fallback indicator, and sends it to the network. The UE uses an RRC UL INFORMATION TRANSFER message. The eNB sends this to the MME using a UL NAS TRANSPORT message.
2-3	The MME prepares an S1AP message (UE CONTEXT MODIFICATION REQUEST) containing the CS fallback indicator, and sends it to the eNB to request CS fallback handling. The eNB transmits a response message (UE CONTEXT MODIFICATION RESPONSE) appropriate for Process 2 to the MME.
4	The eNB can instruct the UE to measure the target RAT if it needs the UE's measurement for CS fallback handling (optional).
5	The eNB uses the Cell Change Order procedure for the CS Fallback processing to the GERAN. The eNB transmits the MOBILITY FROM E-UTRA COMMAND message containing the PCI and carrierFreq which is applicable to the GERAN target cell to the UE. The UE carries out the cell change order procedure on the GERAN target cell specified by the eNB.
6	The eNB transmits the UE CONTEXT RELEASE REQUEST message to the MME.
7	The MME carries out the procedure for releasing the UE context of the E-UTRAN.
8	After connecting to the GERAN, the UE carries out the RR connection setup procedure. If the LA or RA of the connected GERAN cell is different from the stored information, the location registration procedure (LAU and/or RAU or combined LAU/RAU) is carried out.
9-10	When the UE or the target GERAN cell does not support the Dual Transfer Mode (DTM), the UE starts the Suspend procedure. When the Suspend request is received from the UE, the SGSN processes the Suspend Request/Response procedure with the MME.
11	The MME carries out the suspension processing for the non-GBR bearer (s) of the S-GW/P-GW and the deactivation processing of the GBR bearer (s). Afterward, the MME manages the UE context in the suspended status.
12	The UE transmits the CM SERVICE REQUEST message to the UTRAN to carry out next procedure for the CS call setup.

4.2 Data Message Flow

Sending Path

The user data received from the EPC is transmitted to the eNB UADU through the Ethernet switch after passing the network interface module. The transmitted user data goes through baseband-level digital processing before being configured for the CPRI, and then E/O converted. The converted signal is transmitted to the L8HU that is located remotely through an optic cable. L8HU operates the O/E conversion on the transmitted optic signal. The converted baseband signal from the broadband is converted into an analog signal and sent through the high-power amplifier, filter and antenna.

Receiving Path

The RF signal received by the antenna goes through the L8HU filter and low-noise amplification by the LNA.

This signal is then converted into a baseband signal after RF down-conversion and digital down-conversion. It is configured for the CPRI, and goes through E/O conversion again. The converted signal is transmitted to the UADU that is located remotely through an optic cable. The data for which the SC-FDMA signal processing is carried out in the UADU is converted to the Gigabit Ethernet frame and transmitted from the UADU to the EPC via the GE/FE.

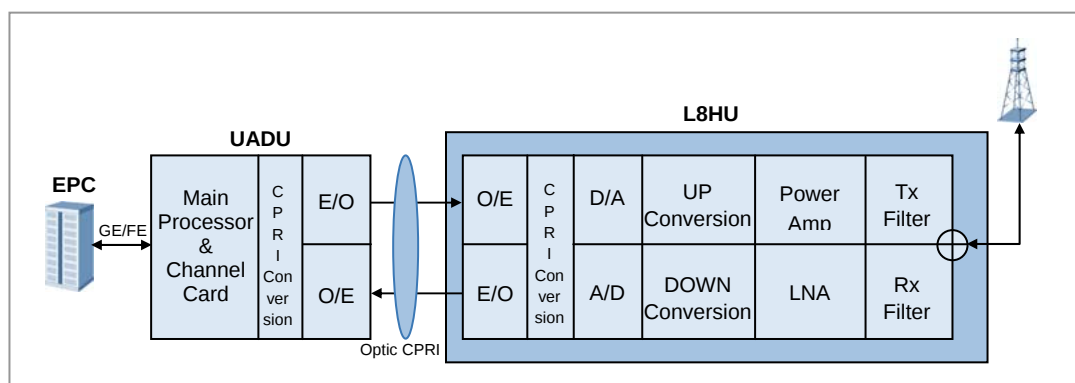


Figure 4.12 eNB System Control and Traffic Flow

4.3 Network Synchronization Flow

The eNB uses GPS to synchronize the system. The UCCM is a GPS receiving module in the UADU, and receives synchronization signals from the GPS to generate/distribute clocks.

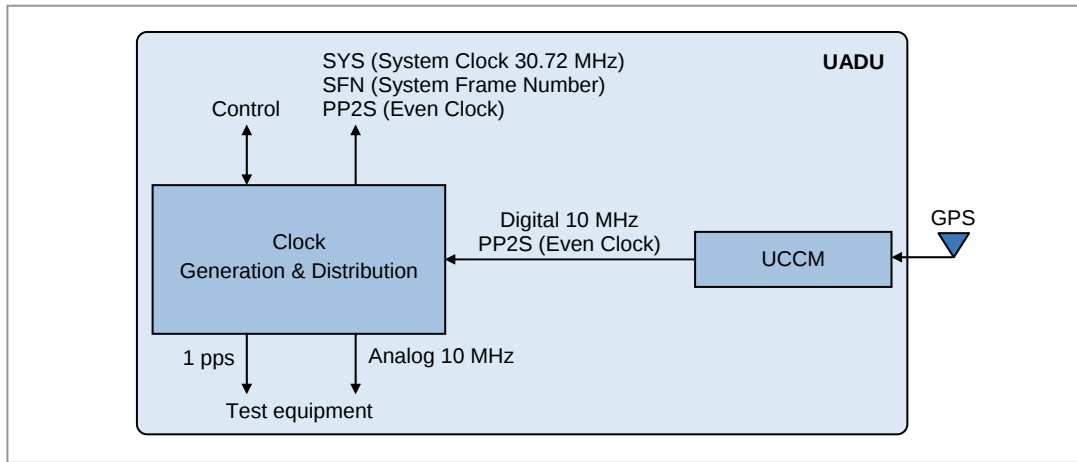


Figure 4.13 eNB Network Synchronization Flow

4.4 Alarm Signal Flow

An environmental fault or hardware mount/dismount is reported with an alarm signal, which is collected by the UAMA of the UADU, and then reported to the LTE system manager (LSM). The user can provide custom alarms through the UDA and environmental alarms (flood, door, fire, temperature, etc.) through the ECM, and control the FAN in the rack. The following alarms are collected by the UAMA:

Alarm Type	Description	Target to Apply
Function Fail Alarm	Fault alarm due to software/hardware problems defined as 'function fail'	L9CA, UAMA
Power Fail Alarm	Fault alarm due to power problems	L9CA, UAMA
Deletion Alarm	System report alarm due to hardware mount/dismount	L9CA
Environmental Fault Alarm	Alarms for the rectifier, flood, fire, FANM-B2, door, control, etc.	System
UDA	Custom Alarm by the operator	UAMA

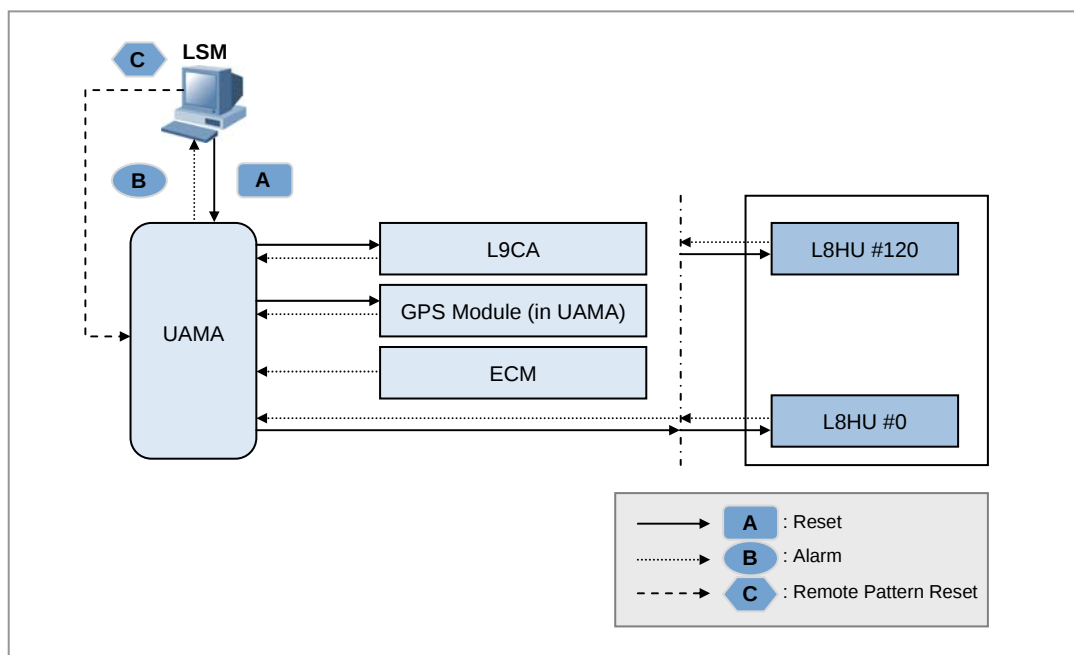


Figure 4.14 eNB System Alarm Flow

4.5 Loading Flow

Loading is a process that downloads, from the LSM, software executables, data, etc. required by the eNB's processors and devices to operate.

The eNB's loading is run during system initialization. Loading can also be run when a board is mounted on the system, hardware is reset, or the high-level system operator restarts a board.

On the first system initialization, the eNB is loaded through the LSM. As the loading information is stored in the internal storage, no unnecessary loading is carried out afterward. When comparing versions after initialization, if the information stored in the internal storage is the latest information, remote loading is not carried out.

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

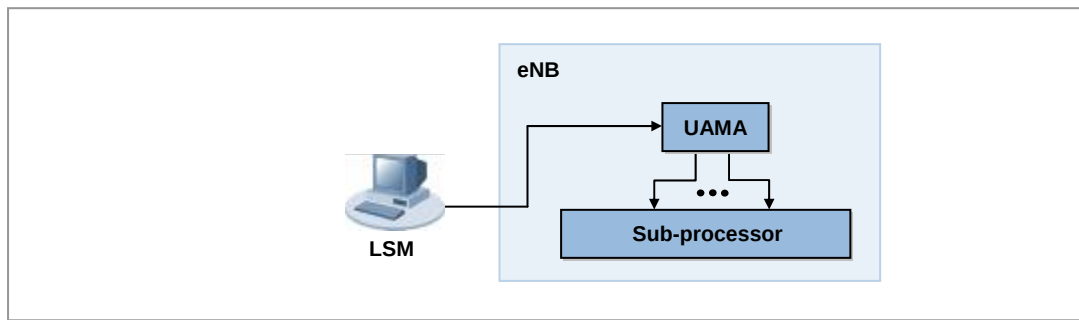


Figure 4.15 Loading Signal Flow

4.6 Operation and Maintenance Message Flow

The operator can view/change the eNB status through the system manager. To do this, the eNB has an SNMP agent through which the LSM operator can run eNB operations and maintenance remotely. The operator can also perform Web-EMT-based maintenance activities using the web browser in the console terminal or through the CLI using telnet/SSH access.

The statistical information provided by the eNB is given to the operator in accordance with the collection interval.

Operation and Maintenance Message Flow

The eNB operation and maintenance occur through SNMP messages between the SNMP agent in the main OAM and the LSM's SNMP manager.

The eNB processes various messages from the LTE's SNMP manager, and reports the results back to the manager as well as reporting real time if events such as faults or status changes occur. The operation and maintenance signal flow is shown below.

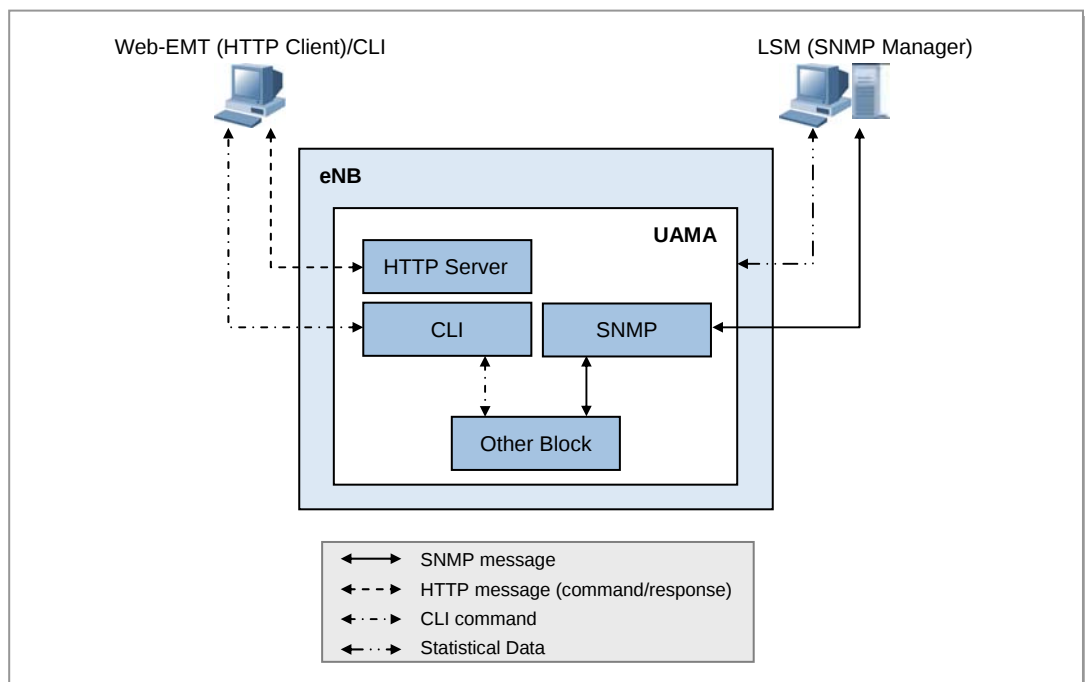


Figure 4.16 Operation and Maintenance Signal Flow



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CHAPTER 5. Supplementary Functions and Tools

5.1 Web-EMT

The Web-EMT is a GUI-based console terminal and tool for device-monitoring, operation, and maintenance through direct access to the eNB. The operator can run the Web-EMT using Internet Explorer, without installing additional software. The GUI is provided using the HTTPs protocol internally.

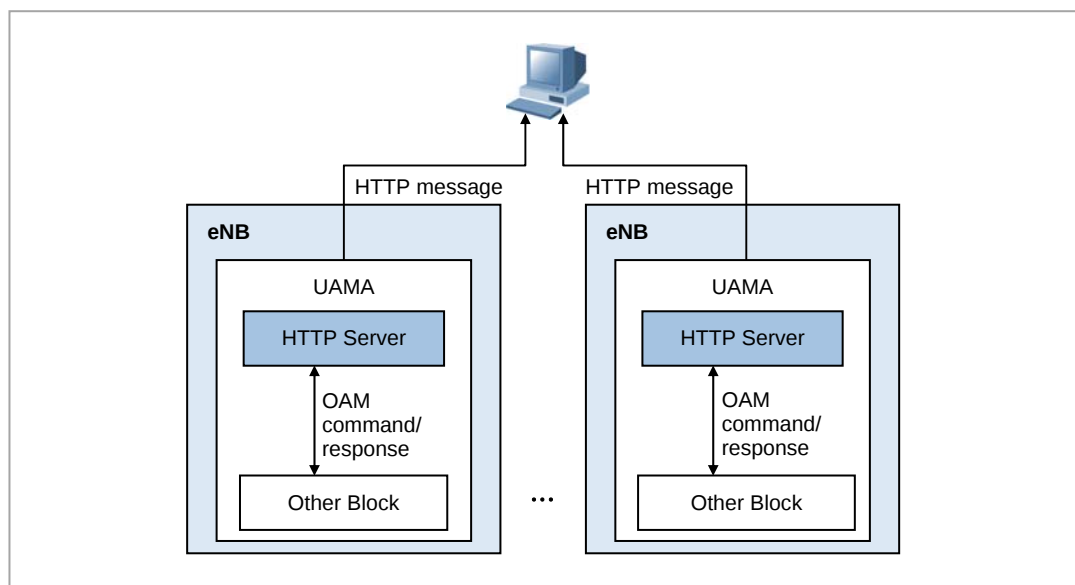


Figure 5.1 Web-EMT Interface

The operator can use the Web-EMT to restart the eNB or internal boards, view/set configuration and operation parameters, monitor statuses and faults, and run a diagnosis. However, increasing/decreasing resources or changing operational information on neighbor lists is possible only through the LSM which manages the entire network and loaded image.

5.2 CLI

The CLI can be used for eNB operations and maintenance. The operator can log onto the eNB via telnet over the PC that is allowed access through the eNB Ethernet, and perform operations/maintenance via the text-based CLI.

Below are the functions the CLI provides.

Loading

The CLI loads programs required by the eNB. It can initialize the eNB normally without working with the LSM, and load specific devices selectively. The CLI can also reset or restart the boards.

Configurations Management

The CLI can run man-machine commands (MMC) to view or change the eNB's configurations.

Status Management

The CLI manages statuses of the eNB's processor and various devices.

Fault Management

The CLI checks the possibility of faults in the eNB's processor and various devices, and provides the operator with fault locations and details. The CLI displays both hardware and software faults, so the operator can check all failures that occur in the eNB.

Diagnosis and Test

The CLI can run a diagnosis on connection paths, processors and other devices that the eNB is running, and detect their faults. The major test functions that the CLI can perform include measuring the sending output and the antenna diagnosis function, etc.



ABBREVIATION

3GPP	3rd Generation Partnership Project
64 QAM	64 Quadrature Amplitude Modulation

A

AC	Admission Control
ACL	Access Control List
ADC	Analog to Digital Converter
AKA	Authentication and Key Agreement
AM	Acknowledged Mode
AMBR	Aggregated Maximum Bit Rate
ANR	Automatic Neighbor Relation
ARQ	Automatic Repeat Request
AS	Access Stratum

B

BGP	Border Gateway Protocol
BSS	Base Station System

C

C & M	Control & Maintenance
CC	Chase Combining
CLI	Command Line Interface
CM	Configuration Management
CoS	Class of Service
CPLD	Complex Programmable Logic Device
CPRI	Common Public Radio Interface
CPS	Call Processing Software
CS	Circuit Service
CSAB	CPS SON Agent Block
CSCU	Cold Start Control Unit

D

DAC	Digital to Analog Converter
DBMS	Database Management System
DD	Device Driver
DFT	Discrete Fourier Transform
DHCP	Dynamic Host Configuration Protocol
DiffServ	Differentiated Services
DL	Downlink
DSCP	Differentiated Services Code Point
DTM	Dual Transfer Mode
DU	Digital Unit
DUS	Debugging Utility Service

E

ECCB	eNB Call Control Block
ECMB	eNB Common Management Block
ECS	eNB Control processing Subsystem
EDS	eNB Data processing Subsystem
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
ES	Energy Saving
ESM	Energy Saving Management
ESM	EPC System Manager
E-UTRAN	Evolved UTRAN

F

FANM-C4	Fan Module-C4
FDD	Frequency Division Duplex
FE	Fast Ethernet
FHS	File-system Hierarchy Standard 2.2
FM	Fault Management
FSTD	Frequency Switched Transmit Diversity
FTP	File Transfer Protocol

G

GBR	Guaranteed Bit Rate
GE	Gigabit Ethernet
GPRS	General Packet Radio Service
GPS	Global Positioning System
GTP	GPRS Tunneling Protocol

GTPB	GPRS Tunneling Protocol Block
GTP-U	GTP-User
GW	Gateway

H

HARQ	Hybrid Automatic Repeat Request
HAS	High Availability Service
HETM-FC	Heater Module-FC
HO	Handover
HSS	Home Subscriber Server
HTTP	Hypertext Transfer Protocol
HTTPS	Hyper Text Transfer Protocol over SSL

I

ICIC	Inter-Cell Interference Coordination
ICMP	Internet Control Message Protocol
IDFT	Inverse Discrete Fourier Transform
IETF	Internet Engineering Task Force
IF	Intermediate Frequency
IP	Internet Protocol
IPRS	IP Routing Software
IPSS	IP Security Software
IPv4	Internet Protocol version 4
IPv6	Internet Protocol version 6
IR	Incremental Redundancy

L

L8HU	LTE eNB remote radio Head Unit
L9CA	LTE eNB Channel card board Assembly
LNA	Low Noise Amplifier
LSM	LTE System Manager
LTE	Long Term Evolution

M

MAC	Media Access Control
MACB	Medium Access Control Block
MBR	Maximum Bit Rate
MCS	Modulation Coding Scheme
MDS	Message Delivery Service
MFS	Miscellaneous Function Service
MIB	Master Information Block
MIMO	Multiple-Input Multiple-Output
MMC	Man Machine Command
MME	Mobility Management Entity
MSS	Master SON Server
MU	Multiuser

N

NAS	Non-Access Stratum
NE	Network Element
NP	Network Processing
NPC	Network Processing Control
NR	Neighbor Relation
NRT	Neighbor Relation Table

O

OAM	Operation and Maintenance
OCNS	Orthogonal Channel Noise Simulator
OCS	Online Charging System
O/E	Optic-to-Electric
OFCS	Offline Charging System
OFD	Optic Fiber Distributor
OFDMA	Orthogonal Frequency Division Multiple Access
OS	Operating System
OSAB	OAM SON Agent Block
OSPF	Open Shortest Path First
OSS	Operating Support System

P

PAPR	Peak-to-Average Power Ratio
PCI	Physical Cell Identity
PCRF	Policy and Charging Rule Function
PDCB	PDCP Block
PDCP	Packet Data Convergence Protocol
PDN	Packet Data Network
PDPU	Power Distribution Panel Unit
PDU	Protocol Data Unit
P-GW	PDN Gateway
RLCB	Radio Link Control Block
PLER	Packet Loss Error Rate
PM	Performance Management
PMI	Precoding Matrix Indicator
PMIP	Proxy Mobile IP
PRACH	Physical Random Access Channel
PSS	Primary Synchronization Signal

Q

QCI	QoS Class Identifier
QoS	Quality of Service
QPSK	Quadrature Phase Shift Keying

R

RACH	Random Access Channel
RB	Radio Bearer
RB	Resource Block
RECS-B2	Rectifier System-B2
RET	Remote Electrical Tilt
RF	Radio Frequency
RFS	Root File System
RLC	Radio Link Control
RO	RACH Optimization
RRH	Remote Radio Head
RU	Radio Unit

S

S1-AP	S1 Application Protocol
SC	Single Carrier
SC-FDMA	Single Carrier Frequency Division Multiple Access
SCTB	Stream Control Transmission protocol Block
SCTP	Stream Control Transmission Protocol
SDU	Service Data Unit
SFBC	Space Frequency Block Coding
SFN	System Frame Number
SFTP	SSH File Transfer Protocol
S-GW	Serving Gateway
SIBs	System Information Blocks
SM	Spatial Multiplexing
SMC	Security Mode Command
SMS	Short Message Service
SNMP	Simple Network Management Protocol
SON	Self Organizing Network
SPD	Surge Protect Device
SSH	Secure Shell
SSS	Secondary Synchronization Signal
STBC	Space Time Block Coding
SU	Single User
SwM	Software Management

T

TA	Tracking Area
THS	Task Handling Service
TM	Test Management
TOD	Time Of Day
TrM	Trace Management

U

UADB	Universal platform type A Digital Backplane board assembly
UADU	Universal platform type A Digital Unit
UAMA	Universal platform type A Management board Assembly
UCCM	Universal Core Clock Module
UDA	User Defined Alarm
UDE	User Defined Ethernet
UDP	User Datagram Protocol
UE	User Equipment
UL	Uplink
UTRAN	UMTS Terrestrial Radio Access Network

V

VLAN	Virtual Local Area Network
VSWR	Voltage Standing Wave Ratio

W

Web-EMT	Web-based Element Maintenance Terminal
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LTE eNB System Description

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MPE Information

	Warning: Exposure to Radio Frequency Radiation The radiated output power of this device is far below the FCC radio frequency exposure limits. Nevertheless, the device should be used in such a manner that the potential for human contact during normal operation is minimized. In order to avoid the possibility of exceeding the FCC radio frequency exposure limits, human proximity to the antenna should not be less than 900cm during normal operation. The gain of the antenna is 19.8 dBi. The antenna(s) used for this transmitter must not be co-located or operating in conjunction with any other antenna or transmitter.
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