AtomCell9.0 LampSite Solution White Paper

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HUAWEI TECHNOLOGIES CO., LTD.

Huawei Technologies Co., Ltd.

Address: Huawei Industrial Base
Bantian, Longgang
Shenzhen 518129
People's Republic of China

Website: http://www.huawei.com

Email: support@huawei.com

Contents

1 Overview

Based on possible indoor coverage scenarios, this document describes the Huawei LampSite solution, including different LampSite network architectures for different network modes, network deployment, CPRI ports, operation and maintenance (O&M) solution, and UMTS/LTE wireless networking and network planning and optimization. In addition, this document confirms the validity and advantages of the LampSite solution by providing some commercial application cases.

2 Introduction

The world has witnessed rapid development and popularization of mobile communications, and the wireless network has covered most areas, meeting people's requirements and enriching people's life.

Most base stations are deployed outdoors, so the indoor coverage performance is less good than outdoor coverage performance due to signal transmission attenuation. As a result, the indoor coverage is often complained about.

The development of mobile broadband (MBB) leads to a sharp increase of data services, most of which are performed indoors. This trend makes unsatisfactory indoor coverage more obvious and improvement in the indoor coverage performance and capacity urgent.

In large-sized scenarios, such as the airport and stadium, site acquisition for outdoor base stations is difficult. Even if outdoor base stations are deployed, signals experience server attenuation during transmission. Besides, indoor scenarios are often featured with large area, complex environment, and many obstacles. As a result, outdoor base stations can neither provide good indoor coverage nor meet indoor capacity requirements.

To address this problem, Huawei launches the LampSite solution based on field-proven base stations. The LampSite solution incorporates the newly-developed RRU HUB (RHUB) and pico RRU (pRRU), the baseband unit (BBU), and the digital conversion unit (DCU, only in GSM scenarios), using optical fibers and Ethernet cables for connection between CPRI ports. This solution is characterized by large capacity, flexible configuration, simple engineering construction, and a small number of modules, providing better indoor coverage and meeting capacity requirements.

The following sections describe the LampSite solution, including its application scenarios, product specifications, engineering deployment, CPRI ports, O&M, wireless networking, network planning and optimization, and some successful commercial cases.

3 LampSite Solution

3.1 LampSite Application Scenario Analysis

On a mobile communication network, continuous coverage improvement and capacity expansion have always been demanded. Particularly, in indoor scenarios, signals from macro base stations experience penetration loss, resulting in unsatisfactory coverage. As mobile data services increase sharply with the development of MBB, over 70% of data services are performed indoors, which makes coverage enhancement and capacity expansion urgent in indoor scenarios.

The following features of mobile communication scenarios need to be considered:

- Geographical environment, including the area and obstacles.
- User behavior, including the population density, mobility features, and traffic features.
- Site information, including access requirements, site deployment location, power supply, and availability of auxiliary devices.
- Coverage, indicating existing outdoor signal coverage from neighboring macro base stations.

Based on previous features, typical indoor coverage scenarios can be divided into the following types:

- Stores

  For example, coffee bars, restaurants, and street stores, which are usually 1- or 2-floor high with great depth of room. At these places, people are distributed both indoors and outdoors and rarely move, mostly using data services. The LampSite base station (or the antennas) is usually ceiling-mounted, and backhaul devices are deployed inside the store. The Café de Flore in Paris is a typical example.

- Large stadiums

  For example, shopping malls, supermarkets, and exhibition halls together with surrounding stores. These buildings, mostly built of reinforced concrete, usually have fewer than 10 floors. Within the buildings, some areas are very spacious, and therefore signals experience slight same-floor penetration loss but great inter-floor penetration loss. Consisting of many different functional areas, these buildings are complex in architecture. In addition, the overall area of these buildings is large (for example, from tens of thousands to less than two hundred thousand square meters). These places have a large number of visitors and high population density. The voice services and data services differ a lot in terms of intensity, but both experiencing obvious tidal effect (large traffic volumes during holidays while no traffic during non-business hours). Typical examples include Galeries Lafayette Haussmann (a shopping mall) in Paris, Wal-Mart, and Shanghai International Exhibition Center.

- Transport hub

  For example, airports, railway stations and metro stations. The internal structure of these buildings is complex, with both large open areas and small offices. These places often contain only a few floors with large storey height. Mostly being steel frame buildings, these buildings use the tempered glass as wall material for isolation. Partition deployment is difficult because of site premises coordination. These places have a large area (for example, from several thousands to hundreds of thousands square meters) and centralized large visitor flow, experiencing huge volume of voice services and data services (with traffic differing a lot during busy hours and off-peak hours). At these places, there are high requirements on coverage for mobile uses. At airports, there are many high-end users who use smartphones and require good service experience. Typical examples include the Pudong International Airport and Shanghai Century Avenue metro station.

- Office building

  For example, skyscrapers and hotels. These buildings often have more than ten floors and are built of reinforced concrete, with reflection glass curtain walls or brick wall decoration. Each floor consists of many rooms with good isolation performance, making the calculation of same-floor penetration loss complex and resulting in great inter-floor penetration loss. The first floor is a hall with large storey height, serving as the interaction area between a building and the external. With large areas (from thousands of to hundreds of thousands square meters), these buildings are equipped with a large number of elevators and usually have underground parking lots. The percentage of high-end users is high and the traffic volume of both voice and data service is large. Coverage in elevators must be satisfactory. Typical examples include the Jin Mao Tower and Hotel Sofitel Shanghai.

- Condo

  This type of building has more than ten floors and is built of reinforced concrete, with reflection glass curtain walls. Each floor consists of many rooms, making the calculation of same-floor penetration loss complex and resulting in great inter-floor penetration loss. Of some condos, several floors up from the bottom are shops and stores. With large areas (tens of thousands square meters), these condos are equipped with a large number of elevators and usually have underground parking lots. Users, mostly high-end users, are centralized. The voice traffic volume is large but the data traffic volume is not (because the fixed broadband carries some data services). Macro signal coverage is unsatisfactory in these condos. Typical examples include the Thailand DS Tower.

  The mentioned indoor scenarios, except small stores, are featured with large area, complex structure, heavy traffic, difficult site acquisition and deployment, and demand of private lines for transmission. In some indoor scenarios, the distributed antenna system (DAS) can be used to solve the coverage problem. However, an applicable and competitive indoor coverage solution is still in demand.

3.2 Architecture of the LampSite Solution

To meet mobile communication requirements in indoor scenarios based on indoor coverage features, Huawei launched the LampSite solution to solve existing problems in indoor mobile communication scenarios and better meet the needs of users. The LampSite solution consists of the following modules: baseband processing unit of a base station, aggregation (over CPRI port) module, remote RF module, optional CPRI port extension unit, digital signal combination unit (for GSM networks), and the network management system for the previous modules.

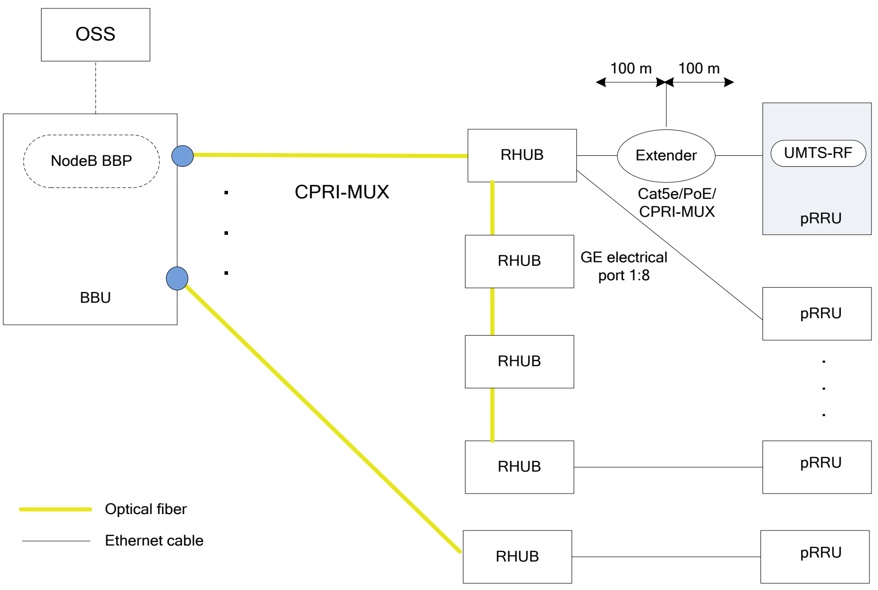
The LampSite solution applies to the following network modes: UMTS only, LTE FDD only, GSM+UMTS, UMTS+LTE FDD, LTE FDD+LTE TDD, single-card dual-mode (UMTS/LTE refarming), and cellular network+Wi-Fi. For details about applications of the LampSite solution in each network mode, see the following sections.

Huawei BBU3900/BBU3910 can house multiple baseband processing units that support one or multiple network modes. Each baseband processing unit has multiple CPRI ports, facilitating flexible configuration in different scenarios.

3.2.1 UMTS LampSite Solution

The UMTS LampSite solution consists of the NodeB BBU, RHUB (aggregation module), pRRU (remote RF module equipped with UMTS RF daughter boards), and the network management system (the U2000). If the cable length between a pRRU and an RHUB is over 100 m, an extender can be used to extend the total cable length to 200 m between them, as shown in Figure 3-1.

Figure 3-1 Networking of the UMTS LampSite solution



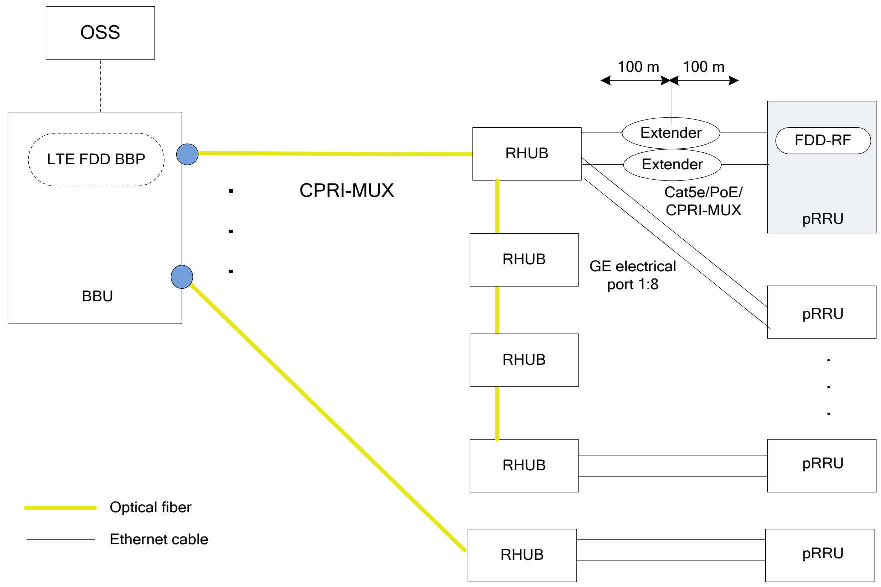
The NodeB BBU can house multiple BBP boards and each BBP board supports three or six CPRI ports (depending on the BBP type) which can connect to three or six groups of RHUBs. Each RHUB group consists of four cascaded RHUBs and each RHUB can connect to a maximum of eight pRRUs. Optical fibers are used for connection between a BBU and an RHUB and between RHUBs. CAT5e or CAT6 Ethernet cables are used for connection between a pRRU and the RHUB and for power supply to the pRRU through power over Ethernet (PoE). In addition, the RHUB and pRRUs are managed by the U2000.

3.2.2 LTE FDD LampSite Solution

The LTE FDD LampSite solution consists of the eNodeB BBU, RHUB (aggregation module), pRRU (remote RF module equipped with LTE FDD RF daughter boards), and the network management system (the U2000). If the cable length between a pRRU and an RHUB is over

100 m, an extender can be used to extend the total cable length to 200 m between them, as shown in Figure 3-2.

Figure 3-2 Networking of the LTE FDD LampSite solution



The eNodeB BBU supports six CPRI ports, which can connect to six RHUB groups. Each RHUB group consists of four cascaded RHUBs and each RHUB can connect to a maximum of eight pRRUs. Optical fibers are used for connection between a BBU and an RHUB and between RHUBs. CAT5 or CAT6e Ethernet cables are used for connection between a pRRU and the RHUB and for power supply to the pRRU through PoE. In addition, the RHUB and pRRUs are managed by the U2000.

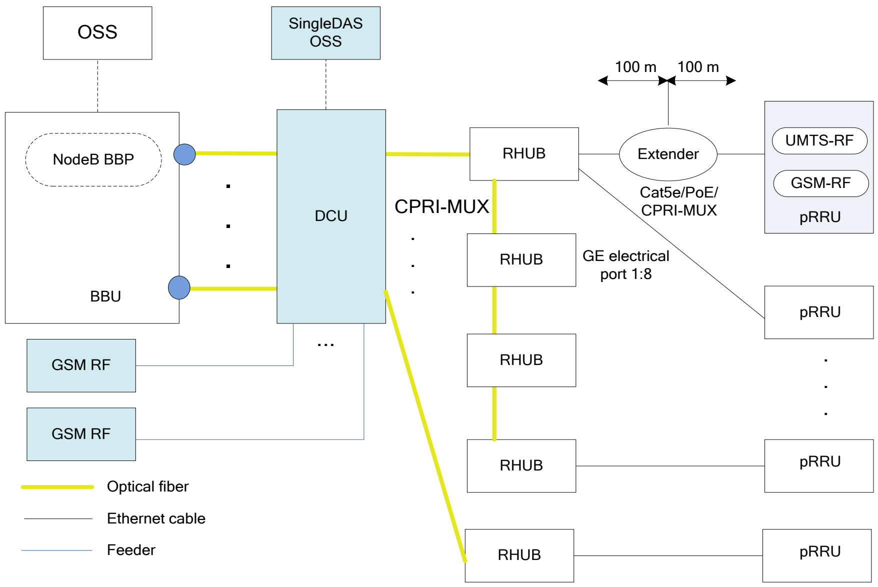
Compared with UMTS inphase and quadrature (IQ) signals, LTE IQ digital signals occupy higher bandwidth. This requires that each pRRU be equipped with two CAT5e Ethernet cables. Install one or two Ethernet cables for each pRRU based on the actual network situation.

3.2.3 GSM+UMTS LampSite Solution

Huawei provides the GSM+UMTS LampSite solution for GSM+UMTS indoor coverage scenarios. In addition to modules involved in the UMTS LampSite solution, a DCU is required and GSM RF daughter boards must be added to the pRRU for the GSM+UMTS LampSite solution.

The GSM+UMTS LampSite solution consists of the NodeB BBU, DCU, RHUB (aggregation module), pRRU (remote RF module), and the network management system (the U2000). If the cable length between a pRRU and an RHUB is over 100 m, an extender can be used to extend the total cable length to 200 m between them, as shown in Figure 3-3.

Figure 3-3 Networking of the GSM+UMTS LampSite solution

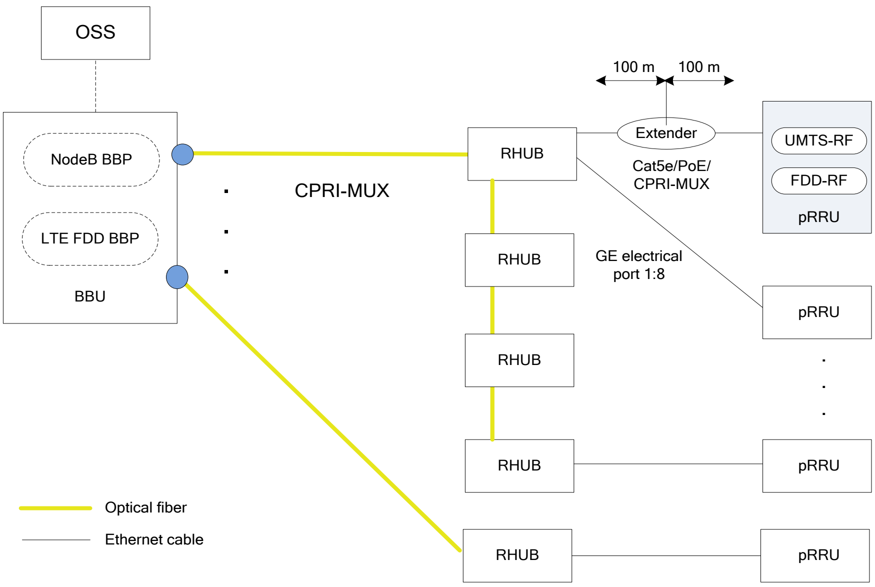


The NodeB BBU supports six CPRI ports, which can connect to the DCU. GSM RF signals, which are sent from the GSM RF module to the DCU, are converted into digital signals and then are combined with UMTS digital signals from the CPRI port of the BBU. In this way, GSM and UMTS digital signals are combined into CPRI-MUX signals, which are sent to the RHUB. Each RHUB group consists of four cascaded RHUBs and each RHUB can connect to a maximum of eight pRRUs. Optical fibers are used for connection between a BBU and a DCU, a DCU and RHUB, and between RHUBs. The feeder is used for connection between a GSM RF module and the DCU. CAT5e Ethernet cables are used for connection between a pRRU and the RHUB and for supply power to the pRRU through PoE. The RHUB and pRRUs are managed by the U2000 for the NodeB and the DCU is managed by the SingleDAS U2000.

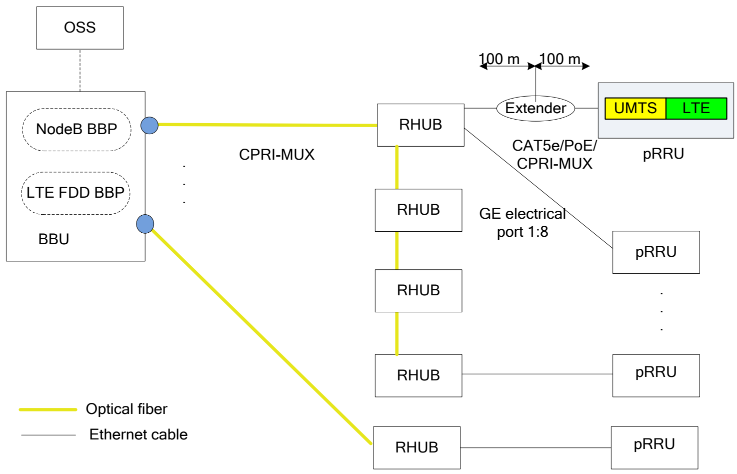
3.2.4 UMTS+LTE FDD LampSite Solution

Huawei also provides the UMTS+LTE FDD LampSite solution for indoor coverage scenarios. The UMTS+LTE FDD LampSite solution consists of the BBU, RHUB (aggregation module), pRRU (remote RF module), and the network management system (the U2000). The BBU must house the baseband processing unit for UMTS and the baseband processing unit for LTE at the same time and the pRRU must be configured with both UMTS and LTE FDD RF daughter boards. If the cable length between a pRRU and an RHUB is over 100 m, an extender can be used to extend the total cable length to 200 m between them. Figure 3-4 shows the networking.

Figure 3-4 Networking of the UMTS+LTE FDD dual-mode (dual-card) LampSite solution



UMTS/LTE refarming can also be used to support the dual-mode solution, as shown in the following figure.



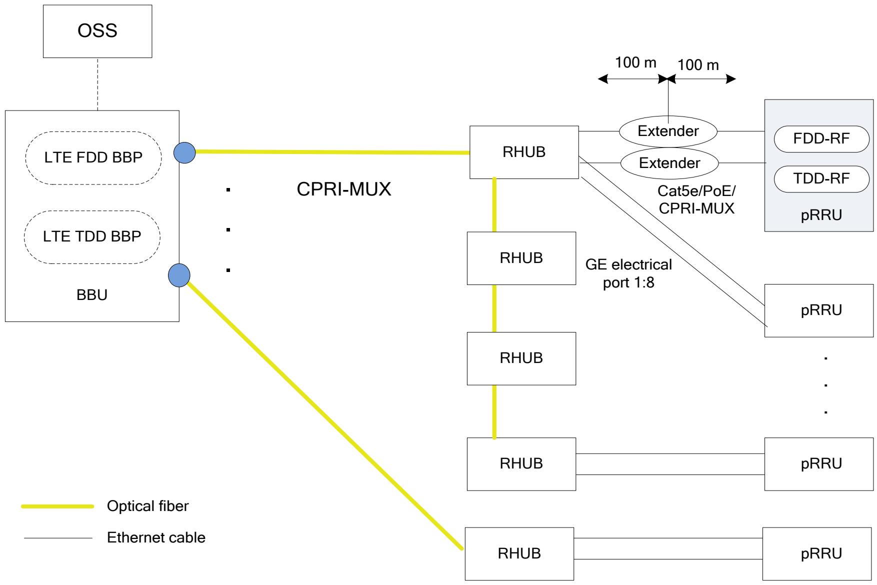
The BBU supports six CPRI ports which can connect to six groups of RHUBs. Each RHUB group consists of four cascaded RHUBs and each RHUB can connect to a maximum of eight pRRUs. UMTS and LTE FDD IQ signals are combined into CPRI-MUX signals in the BBU, and then are forwarded to the RHUB. Optical fibers are used for connection between a BBU and an RHUB and between RHUBs. The RHUB connects to pRRUs over CAT5e or CAT6 Ethernet cables and supplies power to pRRUs through PoE. In addition, the RHUB and pRRUs are managed by the U2000.

3.2.5 LTE FDD+LTE TDD LampSite Solution

Huawei also provides the LTE FDD+LTE TDD LampSite solution for indoor coverage scenarios. One Ethernet cable is sufficient to connect an LTE FDD + LTE TDD pRRU and an

RHUB if the enhanced CPRI compression is used. The LTE FDD+LTE TDD LampSite solution consists of the eNodeB BBU, RHUB (aggregation module), pRRU (remote RF module), and the network management system (the U2000). The BBU must house the baseband processing unit for LTE FDD and the baseband processing unit for LTE TDD at the same time and the pRRU must be configured with both LTE TDD and LTE FDD RF daughter boards. If the cable length between a pRRU and an RHUB is over 100 m, an extender can be used to extend the total cable length to 200 m between them. Figure 3-5 shows the networking.

Figure 3-5 Networking of the LTE FDD+LTE TDD LampSite solution

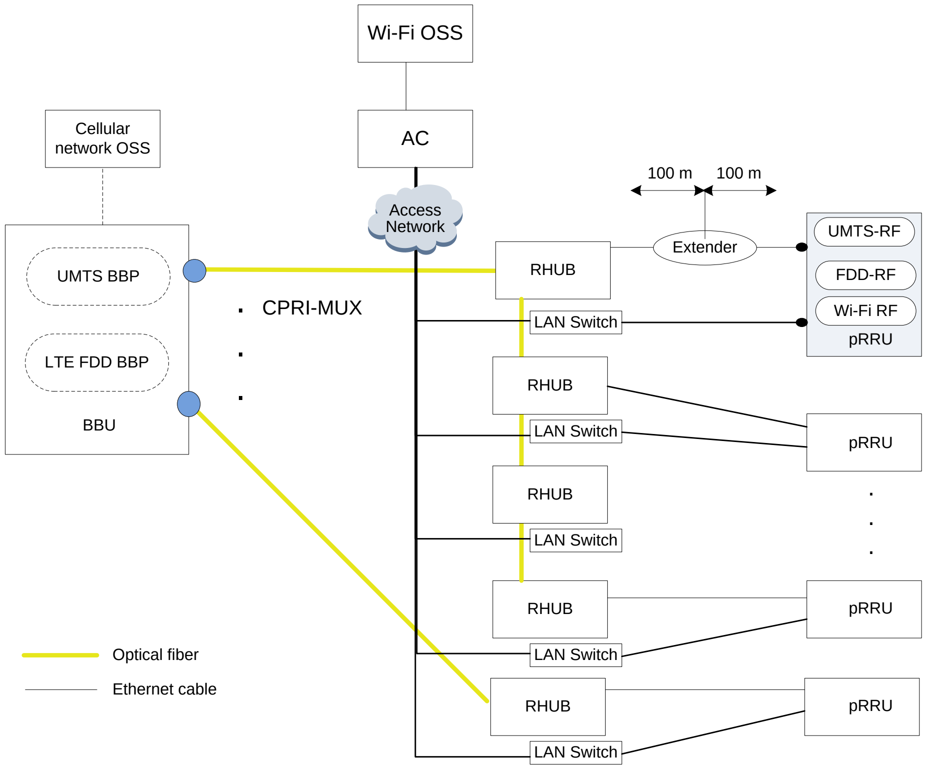


The eNodeB BBU supports six CPRI ports which can connect to six groups of RHUBs. Each RHUB group consists of four cascaded RHUBs and each RHUB can connect to a maximum of eight pRRUs. LTE FDD and LTE TDD IQ signals are combined into CPRI-MUX signals in the BBU, and then are forwarded to the RHUB. Optical fibers are used for connection between a BBU and an RHUB and between RHUBs. The RHUB connects to pRRUs over CAT5e or CAT6 Ethernet cables and supplies power to pRRUs through PoE. The RHUB and pRRUs are managed by the U2000 for the eNodeB.

3.2.6 Cellular Network+Wi-Fi Multimode LampSite Solution

Huawei provides the cellular network+Wi-Fi LampSite solution for indoor coverage scenarios if required. The cellular network in this document refers to a single-mode network, namely, GSM, UMTS, LTE FDD, or LTE TDD network, or refers to a dual-mode network, namely, a combination of any of the preceding two modes. The cellular network+Wi-Fi LampSite solution consists of the BBU, RHUB (aggregation module), pRRU (remote RF module), and the network management system (the U2000). The pRRU must be configured with RF daughter boards for both the cellular network and the WLAN.

Figure 3-6 Networking of the cellular network+Wi-Fi LampSite solution



Specifications of the cellular network+Wi-Fi LampSite solution are the same as those of the single-mode or dual-mode LampSite solution, and therefore are not described here. In Figure 3-6, Wi-Fi RF refers to the AP. The pRRU3901 in AtomCell10.1 is inherited from AtomCell9.0. Wi-Fi data and cellular network data are transmitted through different Ethernet cables, because AtomCell10.1 does not support co-transmission of the cellular network and Wi-Fi data. An independent Ethernet cable must be used to connect the pRRU and the LAN Switch (LSW) to transmit the user-plane and control-plane data for Wi-Fi services. The AP is powered from the RHUB through PoE, and therefore the LSW does not need to support the PoE function. The LSW can be reused on the live network or a newly deployed one sharing an equipment room with the RHUB. The Wi-Fi data is transmitted to the access network through the LSW. Then, the Wi-Fi data is forwarded to the WLAN AC through upper-layer routing and switching devices. The AP is managed by the WLAN OSS because the cellular network OSS cannot manage Wi-Fi devices.

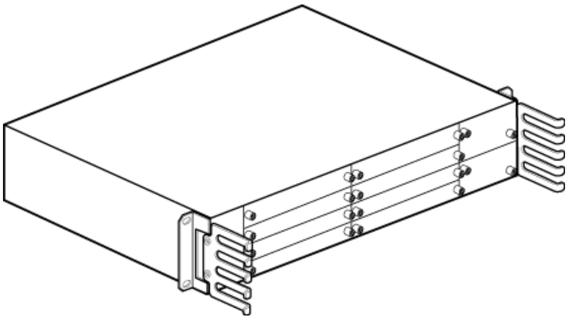
3.3 Product Specifications

The LampSite solution uses the cutting-edge unified module design for multiple network modes, which is applicable to various installation scenarios and reduces deployment and operation costs in terms of site acquisition, capacity expansion, and environment protection of network. The LampSite solution mainly consists of the BBU, RHUB, pRRU and DCU. The following sections describe the specifications of those products.

3.3.1 Appearance

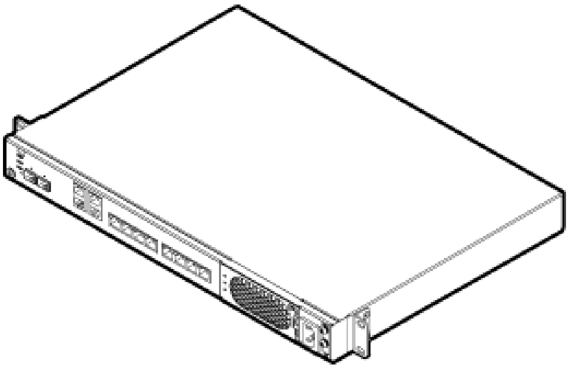
The BBU3900/BBU3910 is a case-shaped device which is 19 inches wide and 2 U high. It can be installed indoors or in an outdoor cabinet with surge protection. Figure 3-7 shows the BBU3900/BBU3910 appearance.

Figure 3-7 Appearance of the BBU3900/BBU3910



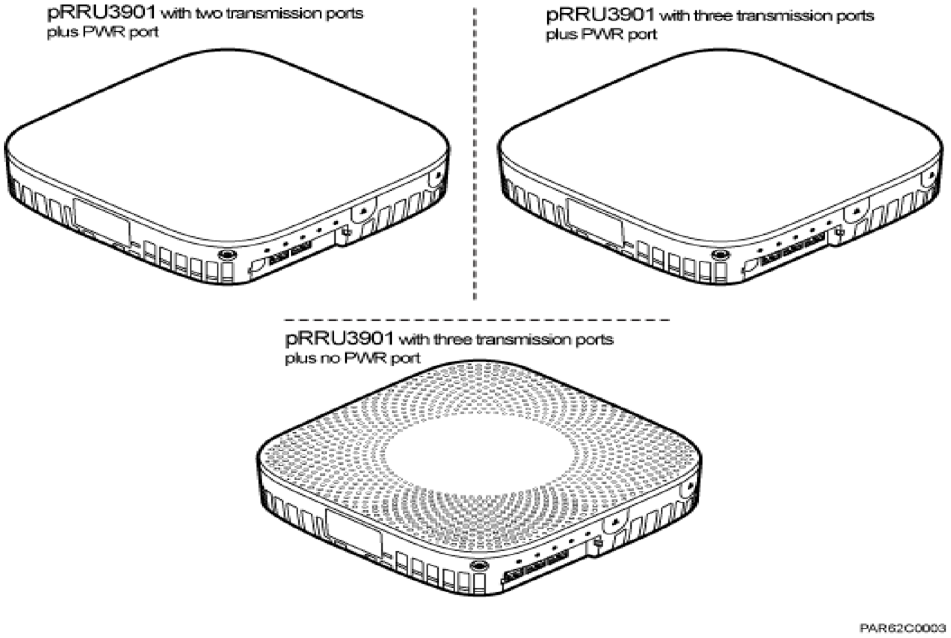
The RHUB3908 is a case-shaped device, as shown in Figure 3-8.

Figure 3-8 Appearance of the RHUB3908



The pRRU is a remote RF module for processing RF signals. Figure 3-9 shows the pRRU3901 appearance.

Figure 3-9 Appearance of the pRRU3901



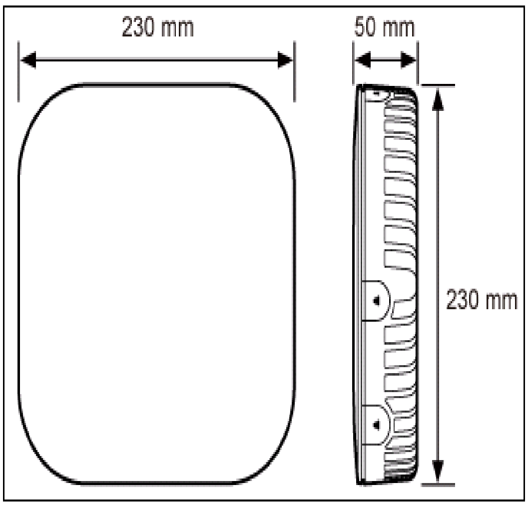
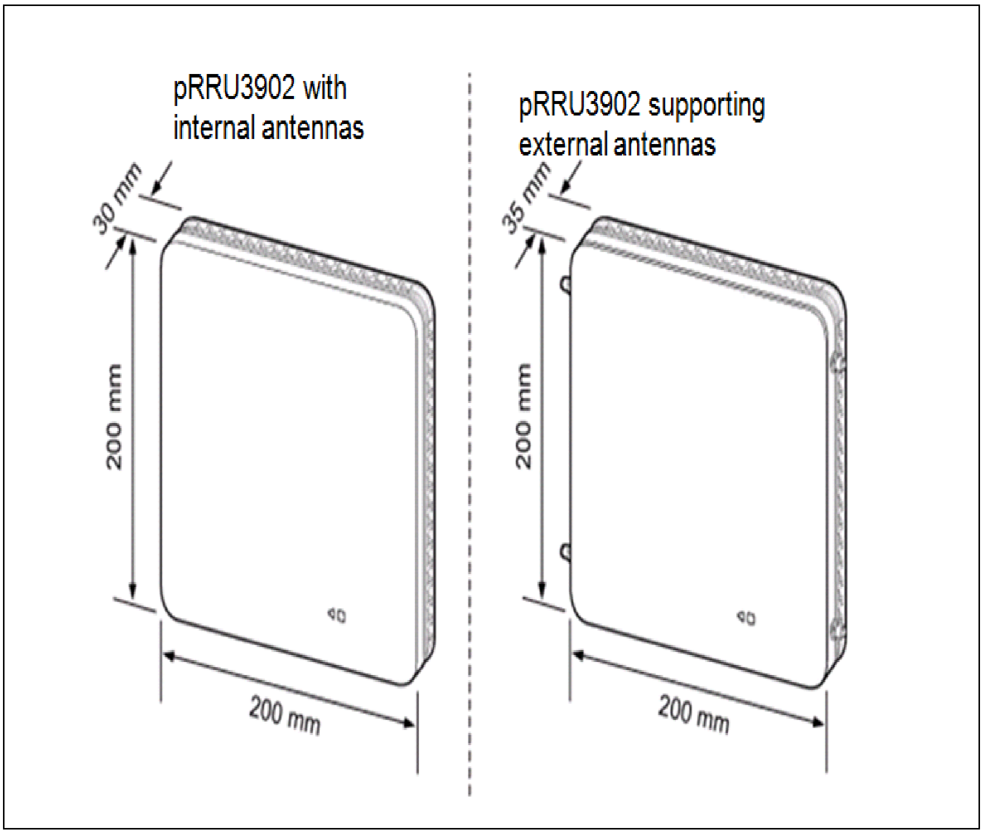


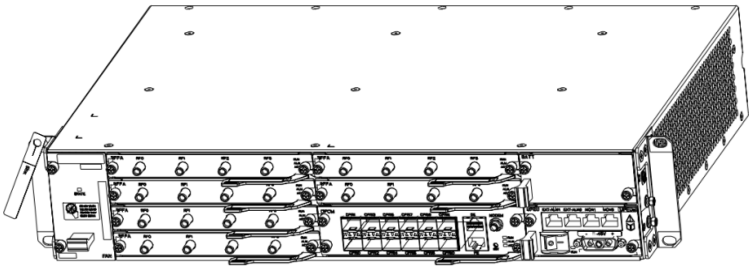
Figure 3-10 shows the pRRU3902 appearance.

Figure 3-10 Appearance of the pRRU3902



In compliance with the IEC60297 standard, the DCU subrack of the DBS3900 IBS has a standard width of 19 inches. The height of each subrack is 2 U. Boards are installed on the front sides of the backplane which is positioned on the rear side of the subrack, as shown in Figure 3-11.

Figure 3-11 DCU Appearance



3.3.2 Technical Specifications

The BBU3900/BBU3910 connects to the RHUB or DCU over the CPRI ports. The number of CPRI ports varies depending on the inserted boards. For details, see Table 3-1.

NOTE

For details about the BBU specifications, see LampSite product specifications.

Table 3-1 CPRI port specifications of the BBU3900/BBU3910

<table>
<tr><th>BBU</th><th>Main Control Board</th><th>Baseband Processing Unit</th><th>CPRI-MUX</th><th>Slot Connected to the UMTS RHUB</th></tr>
<tr><td>BBU3900</td><td rowspan="2">• Global
UMPTb1, UMPTb2, and UMPTb9 (for CL project only and available from eRAN6.1)
• China
UMPTb1, UMPTb2, UMPTb3 or UMPTb4 (TDL CMCC only), and UMPTb9 (for CL project only and available from eRAN6.1)</td><td>• Global
UMTS: WBBPf3 or WBBPf4, and UBBPd1, UBBPd2, UBBPd3, UBBPd4, UBBPd5, or UBBPd6
LTE: LBBPd1, LBBPd3, and UBBPd3, UBBPd4, UBBPd5, or UBBPd6
• China
UMTS: WBBPf3, and UBBPd1, UBBPd2, UBBPd3, UBBPd4, UBBPd5, or UBBPd6
LTE: LBBPd1, LBBPd3, and UBBPd3, UBBPd4, UBBPd5, or UBBPd6</td><td>Either slot 2 or slot 3 supports CPRI-MUX.</td><td>Slot 2 or 3</td></tr>
<tr><td>BBU3910</td><td>• Global
UMTS: UBBPd1, UBBPd2, UBBPd3, UBBPd4, UBBPd5, or UBBPd6
LTE: UBBPd3, UBBPd4, UBBPd5, or UBBPd6
• China
UMTS: UBBPd1, UBBPd2, UBBPd3, UBBPd4, UBBPd5, or UBBPd6
LTE: UBBPd3, UBBPd4, UBBPd5, or UBBPd6</td><td>Any one of slots 0 to 5 supports CPRI-MUX.</td><td>Any one of slots 0 to 5</td></tr>
</table>

Table 3-2 lists physical specifications of the BBU3900/BBU3910.

Table 3-2 Physical specifications of the BBU3900/BBU3910

Item	Specification
Power supply	–48 V DC. Voltage range: –38.4 V DC to –57 V DC
Dimensions (H x W x D)	86 mm x 442 mm x 310 mm

Item	Specification
Weight	BBU3900/BBU3910 ≤ 12 kg (full configuration) BBU3900/BBU3910 ≤ 7 kg (typical configuration)

The RHUB3908 is the CPRI data aggregation center, supporting communication between pRRUs and BBUs. The RHUB combines the baseband data from the BBU and sends them to the pRRUs in the downlink, and combines the baseband data from the pRRUs and sends them to the BBU in the uplink. It has built-in PoE circuits through which the pRRUs get power supply.

Table 3-3 lists the physical specifications of the RHUB3908.

Table 3-3 Physical specifications of the RHUB3908

Item	Specification
Power supply	Single-phase 110 AC (100 V to 200 V) Single-phase 220 AC (200 V to 240 V) 50 Hz/60 Hz Power efficiency: 85% (without PoE)
Dimensions (H x W x D)	1 U (43.6 mm x 482 mm x 310 mm)
Weight	≤ 6 kg
Power consumption	≤ 323W = (30 W + 32 W x 8) x 88.5% RHUB ≤ 30W without AC power loss Power efficiency: 88.5% (The efficiency varies with load.) Prerequisite: The average distance between an RHUB and a pRRU is no more than 100 meters. ≤ 437W = (30 W + 46 W x 8) x 91% RHUB ≤ 30W without AC power loss Power efficiency: 91% (The efficiency varies with load.) Remarks: • AtomCell8.1 and AtomCell9.0 support two RF daughter boards. • Cable loss must be considered.

Item	Specification
Transmission port	CPRI0&CPRI1: to BBU 1: CPRI x 2 (SFP + compatible eSFP): • CPRI0 or CPRI1 used to connect BBU or another RHUB • 9.8 Gbit/s x 2; Each port is backward compatible with the following rates: 1.25 Gbit/s/2.5 Gbit/s/4.9 Gbit/s/9.8 Gbit/s PWR0 to PWR7/CPRI_E0 to CPRI_E7: to pRRU 2: CPRI_E x 8 (RJ45): PWR/CPRI_E0 to E7 --To connect pRRU Support Crossover and Straight (MDI/MDIX) Ethernet cable adaptive; 1 Gbit/s /Port

Table 3-4 lists the physical specifications of the pRRU3901.

Table 3-4 Physical specifications of the pRRU3901

Item	Specification
Power supply	PoE CPRI_E0: 1) PoE: Down compliant with Standard PoE (802.3at/af); Output: -48 V/1.04 A Power efficiency: 90% 2) AC/DC adapter (optional): 110 V (100 V to 120 V)/220 V (200 V to 240 V); 50 Hz/60 Hz; Output: +12 V/3.75 A Power efficiency: 85% 3) Length ≤ 200 meters for PoE power supply through the Extender between RHUBs and pRRUs over CAT5e cables
Dimensions (H x W x D)	2.6 L (50 mm x 230 mm x 230 mm)
Weight	RF daughter board: 0.4 kg/0.6/0.75 pDock: 1.2 kg One RF daughter board+pDock: 1.6 kg Two RF daughter boards+pDock: 2.0 kg AtomCell8.1: Two RF daughter boards
Power consumption	≤ 30 W (One RF daughter board configured) ≤ 32 W (One RF daughter board configured with cable loss) ≤ 42 W (Two RF daughter boards configured) ≤ 46 W (Two RF daughter boards configured with cable loss)

Item	Specification
Transmission port	PoE CPRI_E0&CPRI_E1: CPRI port for power supply and transmission: RJ45 x 2: 1) CPRI_E0 (PoE): PoE power supply&CPRI data 2) CPRI_E1: CPRI data only 3) Support Crossover and Straight (MDI/MDIX) Ethernet cable adaptive; 1 Gbit/s /Port; 4) Support star network to RHUB through CPRI_Ex (one RHUB connects to eight or less pRRUs) 5) No optical port 6) GE: Wi-Fi daughter board (AtomCell9.0 only)

Table 3-5 lists RF specifications of the pRRU3901.

Table 3-5 RF specifications of the pRRU3901

Item	Specification			
Frequency band	Network mode	Frequency band (MHz)	RX frequency band (MHz)	TX frequency band (MHz)
	UMTS/LTE	2100	1920 to 1980	2110 to 2170
		AWS	1710 to 1755	2110 to 2155
		PCS	1850 to 1910	1930 to 1990
	GSM/ LTE FDD	1800 (narrowband)	1710 to 1765	1805 to 1860 RX/Uplink: 1710-1765 TX/Downlink: 1805-1860
	LTE FDD	2600	2500 to 2570	2620 to 2690
	LTE TDD	2500	2545 to 2575	2545 to 2575
	Wi-Fi	2400	2400 to 2483.5	
		5000	5150 to 5350, 5470 to 5725, 5725 to 5850	

Item	Specification
Transmit power	LTE: Supports 2T2R 2x2 20 MHz. Max TX power: 2 x 100 mW 2T2R UTMS: 1) ≤ 1 x 200 mW (23 dBm); Step: 0.5 dB; Power control accuracy: ±0.25 dB 1.1) Single-carrier: 1 x 23 dBm (1 x 200 mW) 1.2) Dual-carrier: 11 and 1001configuration: 19 dBm 101 configuration: 16 dBm 1 23 dBm 200 mW 11 22 dBm 160 mW; Per Carrier: 19 dBm 80 mW 101 19 dBm 80 mW; Per Carrier: 16 dBm 40 mW 1001 22 dBm 160 mW; Per Carrier: 19 dBm 80 mW GSM: 50 mW shared by four carriers Wi-Fi: 2 x 50 mW for each frequency band

Table 3-6 lists the physical specifications of the pRRU3902.

Table 3-6 Physical specifications of the pRRU3902

Item	Specification		
Dimensions	Height (mm)	Width (mm)	Depth (mm)
	200	200	• pRRU3902 with internal antennas: 30 • pRRU3902 supporting external antennas: 35
Weight	≤ 1.2 kg		
Input power	PoE: –42.5 V DC to –57 V DC		
Transmission port	Two FE/GE electrical ports		
Power Consumption	≤ 26.5 W		

Table 3-7 lists RF specifications of the pRRU3902.

Table 3-7 RF specifications of the pRRU3902

Item	Specification			
Frequency band	Network mode	Frequency band (MHz)	RX frequency band (MHz)	TX frequency band (MHz)
	UMTS/LTE	2100	1920 to 1980	2110 to 2170
	LTE FDD	1800 (full band)	1710 to 1785	1805 to 1880
Transmit power	If one UMTS carrier is configured, the full TX power is 200 mW. If two UMTS carriers are configured, the TX power is 80 mW per carrier. One LTE carrier supports the transmit power of 200 mW (100 mW for one transmit channel). A UMTS 2.1 GHz+ LTE 2.1 GHz RF daughter board is configured with one UMTS carrier and one LTE carrier. With continuous configuration, the transmit power is 50 mW (UMTS) + 2 x 50 mW (LTE). Two UMTS carrier configuration supports continuous configuration only.			

Table 3-8 lists the DCU specifications of the DBS3900 IBS.

Table 3-8 DCU specifications of the DBS3900 IB

Item	Specification
Power supply	-38.4 V DC to -57 V DC
Dimensions (H x W x D)	86 mm x 442 mm x 310 mm
Weight	≤ 10 kg
Power consumption	< 165 W
Transmission port	Twelve FE/GE optical ports
Input power range	+6 dBm to +16 dBm

3.4 Project Deployment Solutions

The LampSite solution is mainly deployed for large indoor areas, such as office buildings and large stadiums.

The BBU3900/BBU3910 is a case-shaped device which is 19 inches wide and 2 U high. It can be installed indoors or in an outdoor cabinet with surge protection. When deployed indoors, the BBU3900/BBU3910 can be deployed on a rack in an equipment room. If there is no equipment room, the BBU3900/BBU3910 can be mounted on a wall of a power room which must have transmission resources and –48 V DC power, so that the BBU3900/BBU3910 can connect to the RNC through the transmission network.

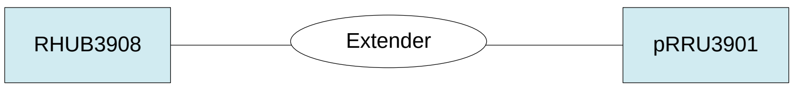
The RHUB3908 is a case-shaped device which can be installed in many ways, such as mounted on the wall, installed in a 19 inch cabinet or rack, or 10 inch cabinet. If a small number of RHUBs are to be deployed, they can be deployed together with the BBU3900/BBU3910 in an equipment room or power room. If a large number of RHUBs are to be deployed, to facilitate cabling, RHUB3908s can be deployed in power rooms close to the designed coverage area.

The pRRU3901/pRRU3902 is small-sized and light-weighted, so it can be mounted on a wall, ceiling, a daughter board of suspended ceiling, a metal pole, or a keel.

In compliance with the IEC60297 standard, the DCU subrack of the DBS3900 IBS has a standard width of 19 inches. The height of each subrack is 4 U. Boards are installed on the front sides of the backplane which is positioned on the rear side of the DCU. The DCU is installed on standard 19 inch rack.

Cabling requirements of optical fibers and Ethernet cables in the LampSite solution are as follows: Optical fibers are used for connection between the BBU3900/BBU3910, DBS3900 IBS DCU, and the RHUB3908 through SFP ports. CAT5e cables are used for connection between the RHUB3908 and pRRU3901/pRRU3902 through RJ45 ports. Generally, the cable length between the pRRU3901/pRRU3902 and RHUB3908 does not exceed 100 m. If the distance between the pRRU3901/pRRU3902 and RHUB3908 is greater than 100 m and does not exceed 200 m, an extender can be used to allow for the Ethernet cable connection, as shown in Figure 3-12. The extender adopts PoE.

Figure 3-12 Using an extender to extend the cable distance



3.5 CPRI Port Solution

CPRI, namely the common public radio interface, is a common standard of the key internal interface between the REC and the RE of the wireless base station. This standard was established by Huawei, Ericsson, NEC, Siemens, and Nortel in June 2003. It aims at standardizing the baseband and RF interface. The major feature of the CPRI is that baseband signals are separated from RF signals to reduce the cost of the engineering construction, equipment room, and equipment.

In Huawei LampSite solution, the BBU and the pRRU are deployed in a distributed way, transmitting signals between each other over CPRI ports. In LTE LampSite solution, the CPRI compression technology is used because LTE signals occupy larger bandwidth.

3.5.1 CPRI Transmission Solution

Figure 3-1 and Figure 3-3 shows that IQ signals are transmitted between the BBU3900/BBU3910, DBS3900 IBS DCU, RHUB3908, and pRRU3901/pRRU3902 over CPRI ports.

The BBU3900/BBU3910 supports three or six CPRI ports (depending on board types). Each CPRI port connects to one RHUB3908 group directly or through a DBS3900 IBS DCU which combines GSM signals. Four RHUB3908s are cascaded as one group over CPRI ports and each RHUB3908 can connect to a maximum of eight pRRU3901s over eight CPRI ports.

Take the UMTS LampSite solution as an example. In the downlink, the BBU3900/BBU3910 transmits the digital IQ signals as follows: Each cell has its own IQ signals. The BBU3900/BBU3910 combines IQ signals of each cell into CPRI-MUX signals and then forwards the CPRI-MUX signals to one RHUB3908 group over the corresponding CPRI port.

In LTE FDD or LTE FDD+LTE TDD mode, the IQ signals require a large bandwidth and one Ethernet cable is enough to connect the RHUB3908 and pRRU to transmit CPRI signals if enhanced CPRI compression is used.

In GSM+UMTS mode, the DBS3900 IBS DCU must be configured to transfer the GSM RF signals into GSM digital IQ signals. Then, the DCU combines the GSM digital IQ signals with IQ signals from the BBU into CPRI-MUX signals and transmits the CPRI-MUX signals to the RHUB over CPRI ports.

3.5.2 CPRI Compression

If IQ signals over the CPRI port require a large transmission bandwidth, CPRI compression can be used to reduce the transmission bandwidth and recover the bandwidth at the receiving end. This technology does not require changing the number of CPRI ports and the transmission line rate.

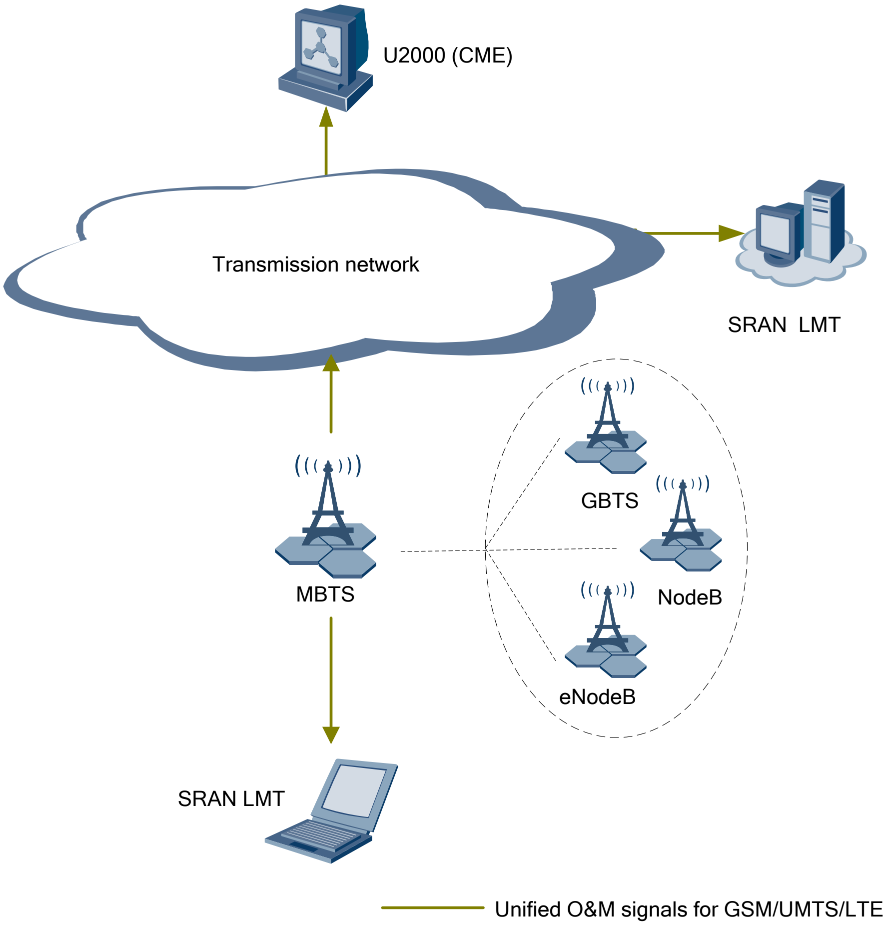
The LTE LampSite solution supports 2:1, 3:1, and 4:1 CPRI compression ration. To be specific, 2:1, 3:1, and 4:1 CPRI compression ratio, by adjusting the IQ digital signal bit width and sampling rate, can reduce the required transmission bandwidth over the CPRI port to 1/2, 1/3, and 1/4 of the original bandwidth, respectively. For UMTS+LTE FDD LampSite solution, 4:1 CPRI compression ratio allows CPRI signals between the RHUB3908 and pRRU to be transmitted over a single Ethernet cable.

3.6 Operation and Maintenance Solution

The LampSite solution provides MML- and GUI-based operation and maintenance (O&M). The OM mechanism is hardware-independent and identical to that used for macro base stations, providing versatile O&M functions to satisfy operators' requirements for operation and maintenance.

The base station O&M system supports two types of operation platforms, namely, SRAN LMT and U2000, to provide local and remote O&M management for base stations, as shown in Figure 3-13.

Figure 3-13 Base station O&M system



SRAN LMT: It is the local maintenance terminal used to configure and maintain GSM, UMTS, and LTE base station services. Maintenance personnel can locally maintain a base station through the Ethernet cable connecting to the Ethernet port for maintenance.

U2000: It is the Huawei centralized O&M system which supports remote management of multiple base stations in a unified way. With U2000, users can perform data configuration (by using the CME), alarm monitoring, performance monitoring, software upgrade, and inventory management.

- Configuration management

  The LampSite solution uses the same BBU as Huawei macro base stations, but uses different RF modules. Similar to a macro base station, the configuration data of both the RHUB and pRRU are managed by the BBU.

  The SmartIBS can be used to generate CME configuration files, improving configuration efficiency.

  One pRRU can house multiple RF daughter boards in different modes, corresponding to multiple sectors and antennas, and therefore each RF daughter board needs to be configured separately.

- Fault management

Fault management is performed on the U2000 for all devices in the LampSite solution. Specially, the fault management can be performed on an RF daughter board level. To be specific, the U2000 can distinguish alarms generated and reported by which RF daughter boards of a pRRU.

The fault pRRU can be quickly located based on the pRRU fault map.

- Performance management

  Generally, network performance management is performed on a cell level. When a pRRU or several pRRUs form one pRRU group to serve one cell, performance management is implemented only for the pRRU group. If the Independent Demodulation of Signals from Multiple Small Cell RRUs in One Cell feature is enabled, certain pRRUs (or pRRU groups) in one cell can perform independent demodulation, and performance KPIs of each pRRU (or pRRU group) can be counted and managed.

- Topology

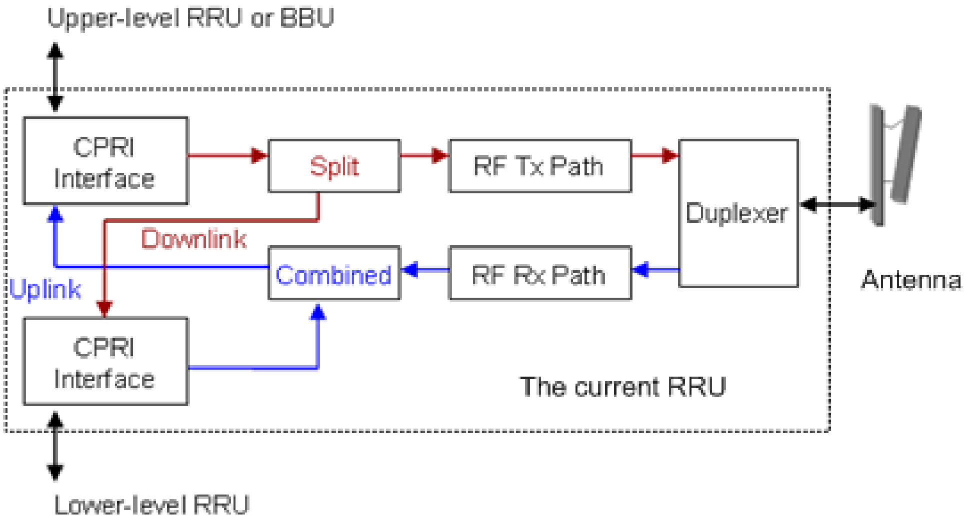
  In the LampSite solution, the BBU, RHUB, and pRRU are connected in chain topology. pRRUs are connected to the RHUB in star topology. Both the topology and module status can be displayed on the U2000.

3.7 Networking for Multiple pRRUs in One Cell in UMTS Mode

Generally, a large number of pRRUs are deployed for complicated indoor coverage. The LampSite solution supports the multiple pRRUs in one cell function to improve network mobility performance and reduce the configuration complexity without having adverse impact on the capacity. A single BBU can connect to up to 96 pRRUs. A maximum of 96 pRRUs can serve one cell (A maximum of 6 channels of independent demodulation with a maximum of 16 pRRUs on each channel). A single site supports a maximum of 24 cells.

In the LampSite solution, digital signal combination and splitting are used to process uplink and downlink signals, as shown in Figure 3-14. In the uplink, digital signals from a pRRU and its lower-level pRRU are combined and then forwarded as a whole to the upper-level RRU or the BBU. In the downlink, digital signals from the upper-level RRU or the BBU are split and forwarded separately to the transmission channel of an RRU and its lower-level RRU.

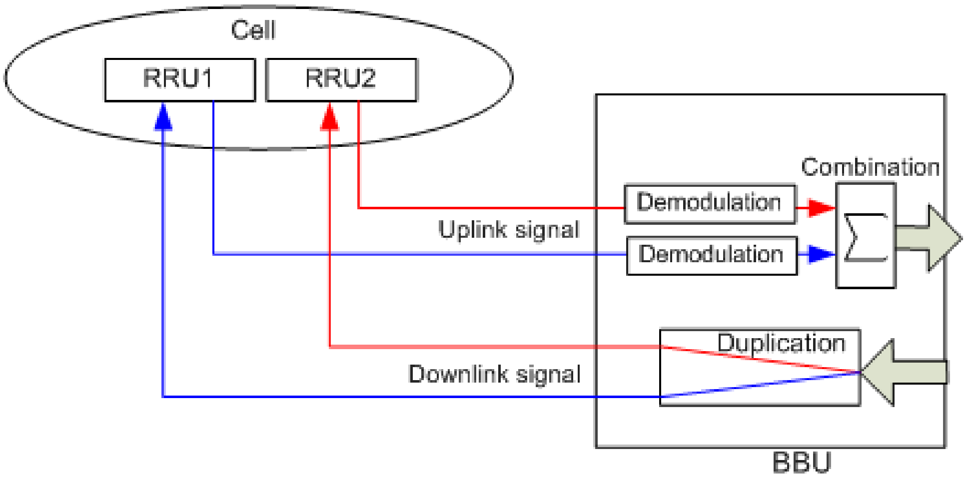
Figure 3-14 Process of uplink signal combination and downlink signal splitting



Uplink signal combination increases background noise. If a cell is served by *n* pRRUs ($n > 1$), the background noise is equal to 10 x lg(n). In indoor coverage scenarios, downlink transmit power is considered more important than the uplink coverage sensitivity, so there is no high requirements on the uplink receiver sensitivity. The Independent Demodulation of Signals from Multiple Small Cell RRUs in One Cell feature can be used to further improve uplink performance.

If this feature is enabled, multiple pRRUs serve one cell to cover different areas. In the downlink, baseband signals are duplicated and then sent to multiple pRRUs for transmission. In the uplink, signals from multiple pRRUs are independently demodulated and then combined in the BBU, as shown in Figure 3-15. Independent demodulation ensures that signal combination for multiple pRRUs does not increase the background noise and guarantees the uplink receiving performance.

Figure 3-15 Independent demodulation and signal combination



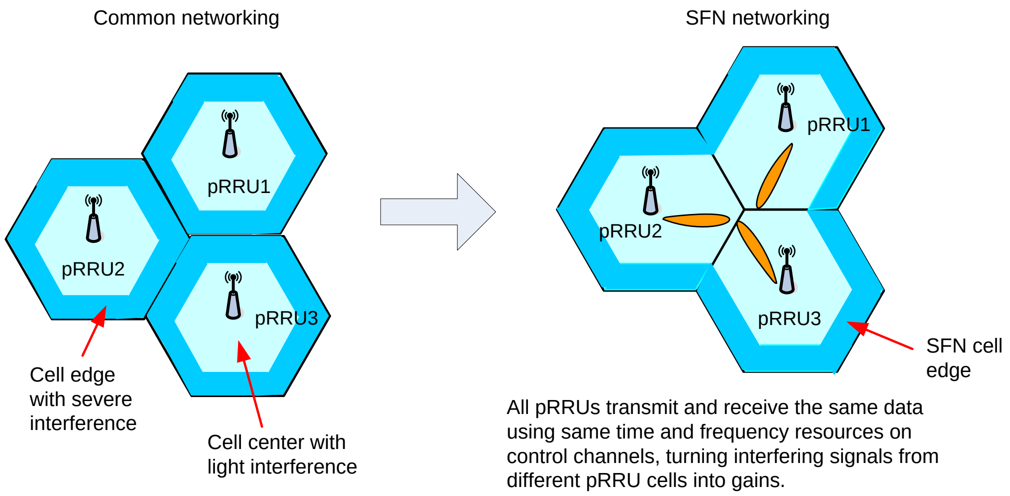
3.8 LTE Wireless Networking Solution

3.8.1 SFN

The single frequency network (SFN) feature allows multiple RRUs that work on the same frequency in a geographic area to serve one cell. In the downlink, all the physical cells use the same time-frequency resources to send the same signals (including signals over control channels and traffic channels). In the uplink, only the physical cell with the best signal quality is selected for reception. In this section, a physical cell is an area covered by one carrier of an RRU.

In the LampSite solution, an SFN cell is covered by multiple pRRUs, so the SFN cell may also be called a multi-pRRU cell. Multiple pRRU micro cells are combined into an SFN cell and each micro cell uses the same physical cell ID. An SFN cell includes multiple (six or less) independent pRRU cells or baseband cells (a baseband cell is a logical cell in which RF signals from multiple pRRUs are combined). Figure 3-16 shows networking of a common LampSite site and an SFN site.

Figure 3-16 Networking of a common LampSite site and an SFN site



In the uplink, signals from multiple pRRUs are independently demodulated and then combined in the BBU, as shown in Figure 3-15. Independent demodulation ensures that signal combination for multiple pRRUs does not increase the background noise while guaranteeing the uplink receiver sensitivity. Multiple pRRUs serve the same cell for UE signal receiving and scheduling. This expands the cell coverage and reduces the number of handovers, which helps reduce the call drop probability. Multiple pRRUs send the same data using the same physical cell identifier (PCI), physical random access channel (PRACH), and control channel. Compared with common networking, the SFN feature clears interference exists between pRRU control channels, allowing joint transmission and reception to deliver greater gains.

The SFN feature improves the network performance:

- Deploying SFN cells in a wide range improves the signal to interference plus noise ratio (SINR) on the entire network.
- The SINR of the PDCCH and PDSCH increases in densely populated outdoor areas. For example, the SINR increases by 2 dB to 3 dB if three common RRUs are combined to serve one SFN cell in a densely populated outdoor area.
- The number of handovers decreases and the handover success rate increases, lowering the service drop rate.

The SFN feature imposes impacts on the system capacity in the following aspects:

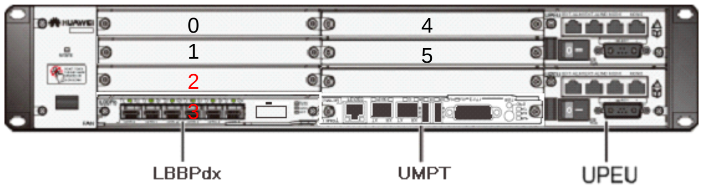
- User experience is improved. To be specific, the average downlink throughput and the edge throughput of a single user increase by 90% and 220%, respectively.
- The average uplink throughput of a single user in an SFN cell is the same as that in common cells.
- The number of scheduled users and the throughput in an SFN cell is lower than that in multiple independent physical cells.

The SFN feature helps control interferences on downlink control channels to enhance user experience in indoor pRRU coverage scenarios. On a new network, the network is lightly loaded and the indoor coverage KPIs are guaranteed. During this stage, deploying micro SFN cells improves user experience, especially for users at the cell edge. For an existing network that is heavily loaded, deploying micro SFN cells guarantees the network performance.

3.8.2 Intra-BBU Baseband Sharing (2T)

In a BBU, different baseband processing units can share baseband resources by using the back plane. For example, in Figure 3-17, baseband resources on boards in slots 0, 1, 4, and 5 are converged to boards in slot 2 or 3, and are forwarded to the RHUB over optical ports (CPRI ports) in slots 2 or 3.

Figure 3-17 BBU panel



If different baseband processing units use the same baseband resources, enabling Intra-BBU Baseband Sharing (2T) reduces the number of optical ports required for connection and lowers engineering deployment costs.

3.8.3 Adaptive SFN/SDMA

During downlink joint transmission and uplink selective reception, the eNodeB determines whether a UE is an independent-scheduling UE or a joint-scheduling UE. The eNodeB allocates time-frequency resources for a UE based on the judgment.

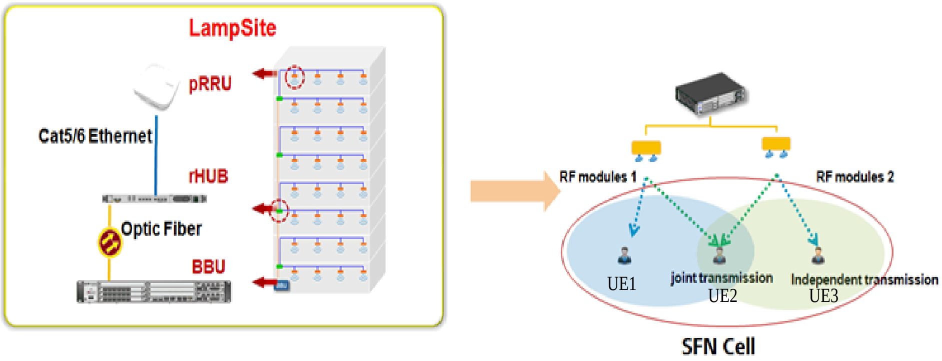
Differences between the Adaptive SFN/SDMA feature and the SFN feature are as follows:

- If the SFN feature is enabled, joint scheduling is always performed for UEs.
- If the Adaptive SFN/SDMA feature is enabled, the eNodeB judges whether a UE is an independent-scheduling UE or a joint-scheduling UE and then allocates an appropriate scheduling mode for the UE based on the judgment.

The eNodeB chooses the scheduling mode for a UE based on the reference signal received power (RSRP) and SINR of the UE. Generally, if a UE experiences severe inter-RF module interferences, the eNodeB choose joint-scheduling for the UE. If a UE experiences slight inter-RF module interferences, the eNodeB chooses independent-scheduling for the UE.

The eNodeB adaptively allocates resources for joint scheduling UEs or independent scheduling UEs, as shown in Figure 3-18.

Figure 3-18 Adaptive independent scheduling and joint scheduling



Joint scheduling is applicable to UEs in the overlapped areas of physical cells, such as UE1and UE2 in Figure 3-18.

Independent scheduling is applicable to UEs in the central areas of physical cells, such as UE3and UE4 in Figure 3-18. In independent scheduling, a UE only uses the time-frequency resources of a single RRU. RRUs in physical cells reuse the time-frequency resources to send different data to different UEs. In Figure 3-18, UE3 and UE4, using the same time-frequency resources, receive data from RRU3 and RRU2, respectively.

The Adaptive SFN/SDMA feature increases the system capacity. Compared with an SFN cell, the average downlink throughput of a cell enabled with the Adaptive SFN/SDMA feature increases by 68%.

3.9 Network Planning and Optimization

The LampSite solution mainly applies to large-scale indoor scenarios. Except planning in frequency, scrambling code/PCI, RF parameters of neighboring cells, network planning of the LampSite solution differs hugely from that of the macro base stations. For example, the site survey and planning are not required for the LampSite solution, but the pRRU deployment position and cell-combining specifications need to be planned. The link budget tools are used to plan the pRRU deployment position and indoor coverage simulation. The co-cell coverage is planned based on the traffic model.

Problems of user experience, network coverage, and interference can be detected by monitoring network performance KPIs. Optimization against such problems can be implemented by optimizing RF parameters, adjusting the pRRU deployment position, increasing the number of pRRUs, and adjusting cell combination schemes. If problems are related to coordination between the macro network and LampSite network, optimization is preferably performed on the LampSite network.

4 Popularization

Incorporating the BBU, RHUB, and pRRU, and using optical fibers and CAT5e cables for connection between CPRI ports, the LampSite solution gives the full play to the advantages of original macro networks. This solution supports flexible cell configuration, large capacity, high performance, and easy deployment, and therefore is ideal for indoor coverage in large- and medium-size indoor stadiums.

Thanks to its advantages such as high performance and easy deployment, the LampSite solution, since its first launches, is well received among operators and is implemented in a wide range of areas.

Some application cases of the LampSite solution deployed for an operator are provided here.

The target coverage area is floor 2, which is sectioned by multiple offices and corridors. The first floor, for the most part, is the office area and business hall. The pRRUs are mounted on the wall or ceiling, as shown in Figure 4-1.

Figure 4-1 pRRU installation position

Due to many compartments in the office area, the coverage environment is complicated. In this case, multiple-pRRU cells and expanded cells are configured to ensure good coverage. In a word, the LampSite solution not only provides good coverage but also significantly improves the system throughput, as shown in Figure 4-2 and Figure 4-3.

Figure 4-2 Coverage provided by the LampSite solution

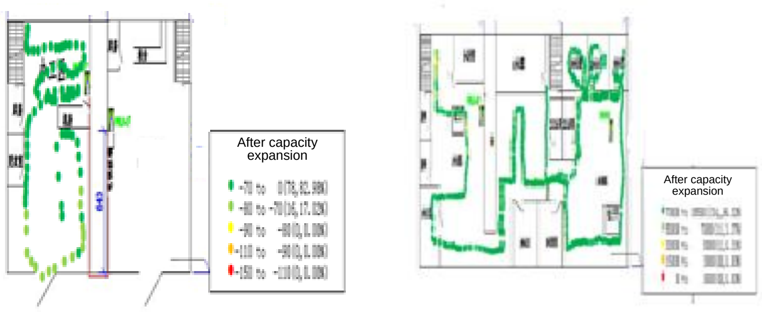
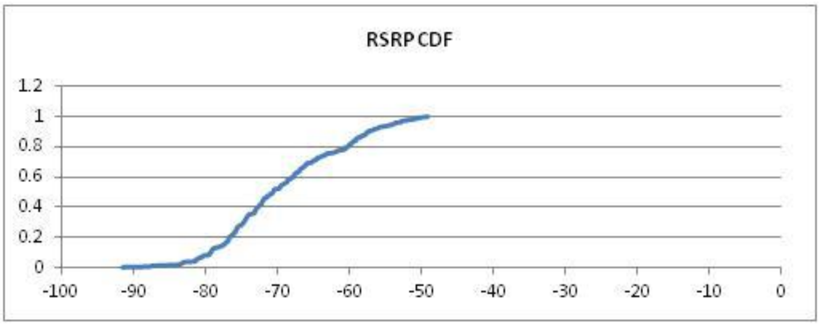


Figure 4-3 RSRP CDF curve of the deployed LampSite solution



The LampSite solution has the following features:

- Easy installation and deployment

  Ethernet cables are used for connection between the RHUB and the pRRU, easily winning deployment admission of the owner. The pRRUs support PoE power supply and are equipped with centralized backup power, facilitating deployment. These advantages help shorten the project duration and reduce project cost in general. Table 4-1 lists the deployment duration.

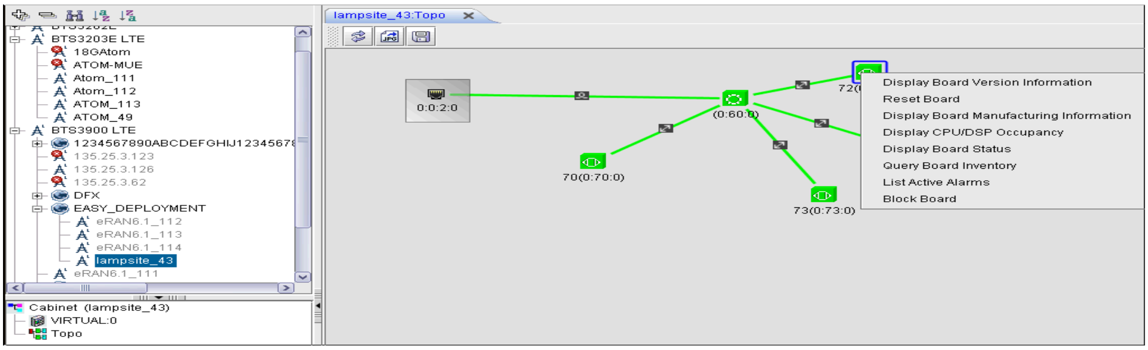
Table 4-1 Deployment duration of the LampSite solution

Item	Duration
BBU+RHUB	1 h
Cabling (Ethernet cable)	1 h
pRRU	About 20 minutes per pRRU

- pRRU-level end-to-end network management

  On the network management system (NMS) of the LampSite solution, you can query the network topology and the pRRU operating status to help detect and solve problems in a timely manner, as shown in Figure 4-4.

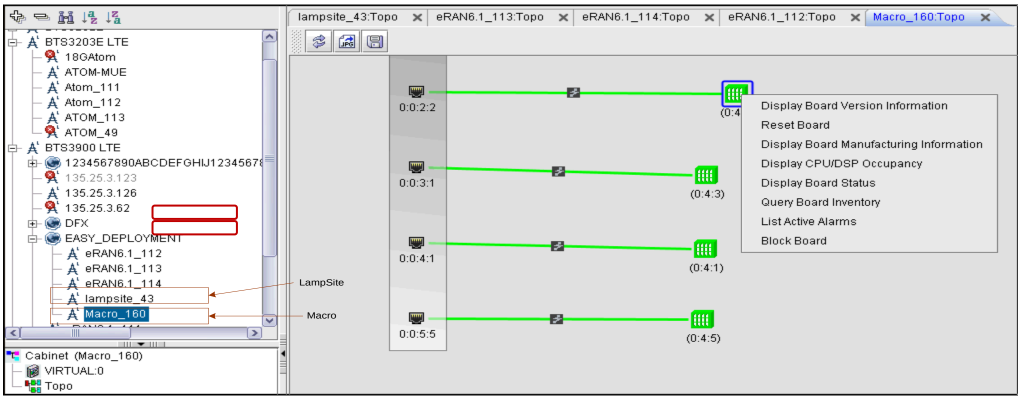
Figure 4-4 NMS of the LampSite solution



- Sharing NMS with macro networks

  The LampSite solution can share one NMS with surrounding macro networks. This facilitates maintenance and reduces O&M costs, as shown in Figure 4-5.

Figure 4-5 Sharing NMS with macro networks



- Easy expansion to provide large network capacity

  The LampSite solution supports a maximum of 24 pRRU cells being combined into one multi-pRRU cell. Besides, the LampSite supports software-based configurations, which allows convenient capacity expansion without a network reconstruction.

- Macro-and-micro coordination planning

  The LampSite solution supports the self-organizing network (SON) function. Neighboring cells can be automatically added and optimized between macro and micro networks, facilitating network planning and optimization.

5 Conclusion

Based on the leading traditional macro base station solutions, Huawei launched the LampSite solution for indoor coverage in large- and medium-scale environments. The LampSite solution inherits the advantages of BBU. In this solution, the BBU and RHUB are connected using optical fibers and the RHUB and pRRU are connected using CAT5e/CAT6 Ethernet cables. A maximum of 96 pRRUs and 24 UMTS cells or 36 LTE cells can be deployed on a single LampSite site. In addition, the LampSite solution supports independent demodulation.

The LampSite solution provides the following advantages:

- Easy installation and deployment: This facilitates engineering construction and reduces deployment costs.
- Easy expansion to provide large network capacity: The LampSite supports software-based configurations, which allows convenient capacity expansion without a network reconstruction.
- Sharing NMS with macro networks: The pRRU share the NMS with macro networks. This reduces O&M costs and facilitates fast fault location.
- Supporting the SON function: This improves macro-and-micro coordination and facilitates network optimization.

In conclusion, Huawei LampSite solution has prominent advantages in project deployment, network performance, and O&M, as demonstrated in multiple commercial application cases.

A Acronyms and Abbreviations

Table A-1 Acronyms and abbreviations

Acronym and Abbreviation	Full Name
BBU	Baseband Unit
CPRI	common public radio interface
DCU	Distributed Control Unit
FE	Fast Ethernet
FDD	Frequency Division Duplex
GE	Gigabit Ethernet
GSM	Global System for Mobile communications
GUI	Graphic User Interface
IQ	Inphase and Quadrature
LMT	Local Maintenance Terminal
LTE	Long Term Evolution
MBB	Mobile broadband
MML	Man-Machine Language
PCI	Physical Cell Identifier
pRRU	Pico Remote Radio Unit
PoE	Power over Ethernet
RE	Radio Equipment
REC	Radio Equipment Controller
RF	Radio Frequency
SFN	Single Frequency Network
TDD	Time Division Duplex

Acronym and Abbreviation	Full Name
UMTS	Universal Mobile Telecommunications System