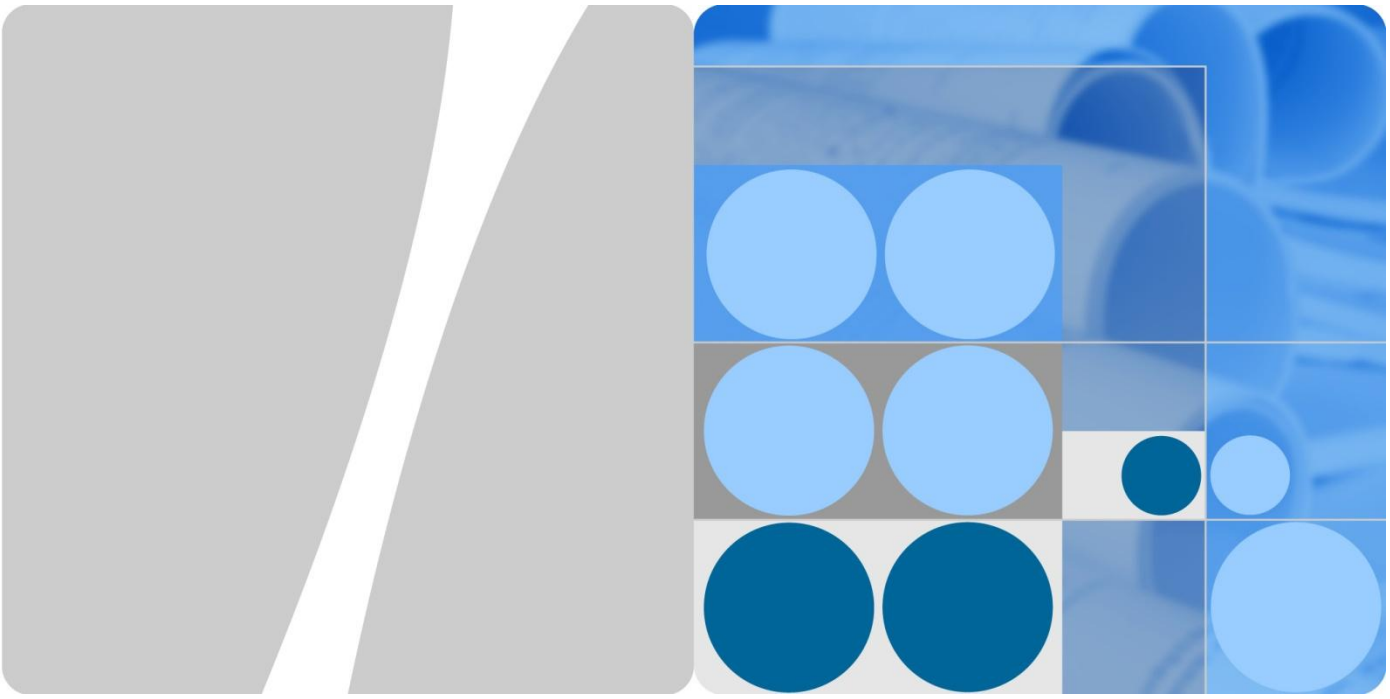

Transmission Solution for Small-Cell Base Stations White Paper

Issue 1.0

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Contents

1 Executive Summary

This document presents end-to-end (E2E) transmission solution for small-cell base stations in terms of the following aspects:

- Flexible last-mile transmission
- Aggregation transmission that reuses existing transmission resources
- Flexible and Unified OM
- E2E transmission security
- Flexible E2E clock synchronization
- E2E transmission QoS
- E2E transmission reliability

It also provides key product information and recommended marketing strategies for the E2E transmission solutions for small-cell base stations. This document can help users better understand application capabilities of small-cell base stations in terms of transmission solutions and facilitate their commercial promotion and deployment.

2 Introduction

2.1 Drivers for Deployment of Small-Cell Base Stations

Widespread use of smartphones and tablet devices and continuous growth of heavy-traffic services are pushing up mobile data traffic volumes to an ever higher pitch. For example, online videos and cloud-based services are generating gigantic data streams every day.

Along with such a significant trend, macro base stations are feeling acutely strained to cope with huge traffic demands by simply increasing outdoor data capacity due to their extreme deployment density in heavy-traffic areas and limited site resources.

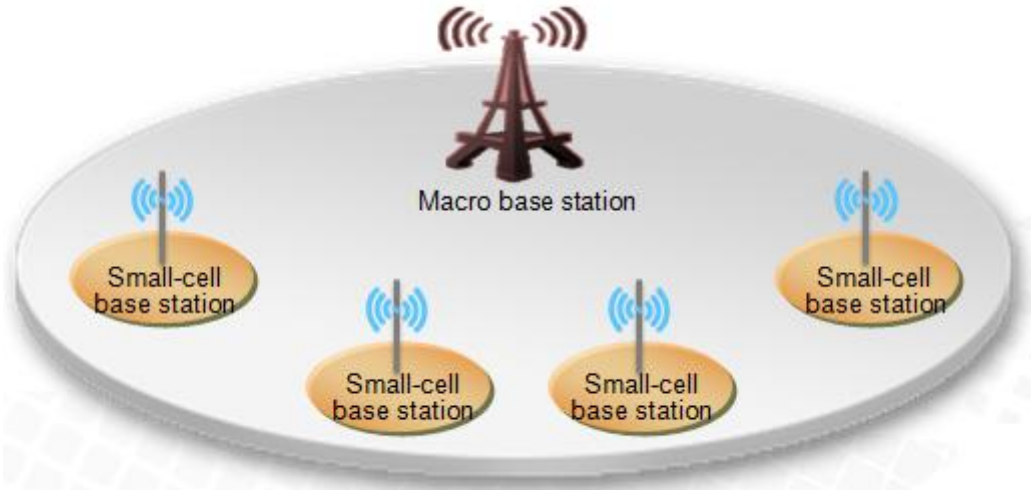
Bring Your Own Device (BYOD) programs are thriving and driving up indoor traffic contributions in areas such as shopping malls and railway stations thanks to booming mobile and smart devices. This noticeable trend is also forcing traditional macro base stations out of practice to meet the demands of enormous indoor data volumes generated on mobile and smart devices.

Urgency is intensifying for evolution to a radio access technology that can support soaring mobile traffic while maintaining sound service experience for all users.

Common practice to meet this challenge is to overlay low-powered base stations on traditional macro networks to increase network capacity and enhance network coverage. Lower-powered base stations are also referred to small-cell base stations, including micro base stations and pico base stations. This new network model is more commonly termed as HetNet networks, with which network capacity can be maximized while delivering good user experience at low operation costs.

Figure 2-1 shows the diagram of a HetNet network.

Figure 2-1 Diagram of a HetNet network



2.2 Challenges for Small-Cell Base Station Transmission

Challenges for transmission solutions of small-cell base stations are two-fold: huge deployment quantity and various deployment places.

Deployment quantity of small-cell base stations:

An enormous number of small-cell base station deployments have already been forecast in this industry. Industry analysis also shows that small-cell base station will far outnumber macro base stations in terms of application scales. Therefore, dense deployment, operation, and maintenance of small-cell base stations will pose serious challenges to operators on how to achieve cost effective applications of small-cell base stations.

Deployment places of small-cell base stations:

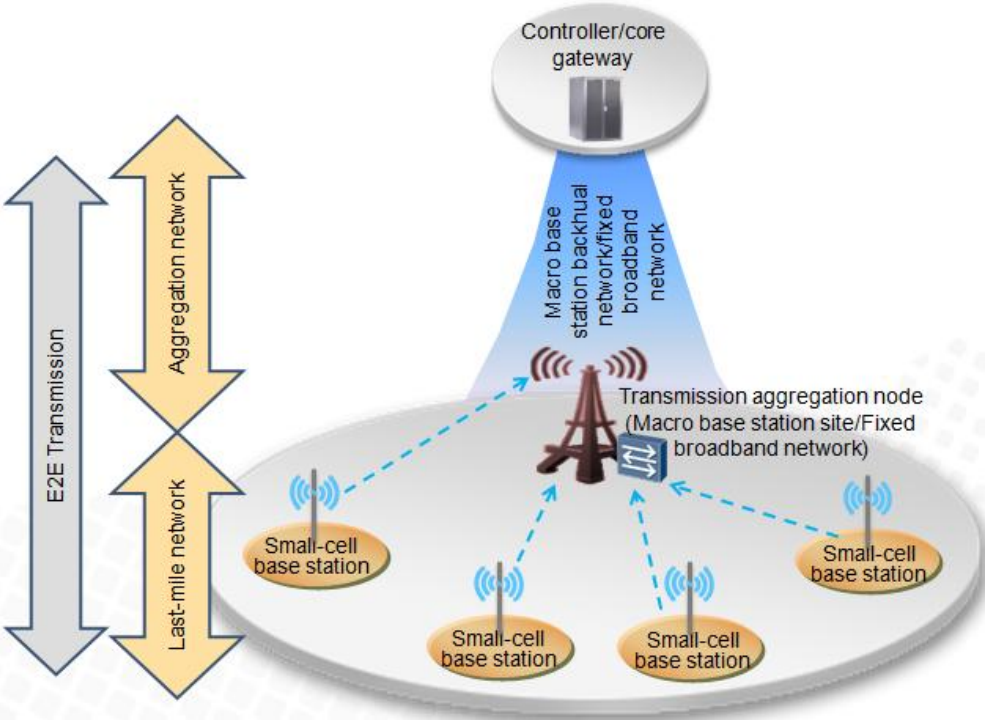
Small-cell base stations apply different deployment modes from macro base stations. Besides, small-cell base stations can be deployed flexibly at different sites. For example, they can be deployed in indoor hotspots, such as office buildings, stadiums, and shopping malls. At the same time, they can also be deployed on traffic light poles, streetlight lamp poles, electricity poles, and external walls of buildings in outdoor areas, such as business streets and squares. Support of flexible deployment raises important challenges to operators on how to fully maximize the potentials of this feature.

2.3 Definition of Small-Cell Base Station Transmission

E2E transmission for small-cell base stations refers to end-to-end connections that can achieve desired QoS requirements between a small-cell base station and a core node. A core node can be an RNC (on UMTS networks), an AC (on a WLAN), or an MME and an S-GW (on an LTE network). The E2E transmission is implemented by an E2E transmission network.

Figure 2-2 gives a diagram of an E2E transmission network for small-cell base stations.

Figure 2-2 E2E transmission for small-cell base stations



As shown in Figure 2-2, an E2E transmission network includes two integral components:

- Last-mile network: Connects a small-cell base station and a transmission aggregation node.
- Aggregation network: Cover a transmission aggregation node and a core node to aggregate data traffic from a small-cell base station to the core node.

During a traditional macro base station deployment, a new transmission network is often built between a macro base station and a core node. Different from such traditional deployments, the first choice for transmission networks of a small-cell base station is to reuse existing aggregation transmission resources for the sake of deployment costs.

For example, transmission networks for existing macro base stations or fixed broadband networks are commonly used in small-cell base station deployment. The transmission aggregation node is the node that connects to existing transmission network nodes, such as macro base stations site equipment (macro base stations or cell site gateway) or access node for wired broadband services, either owned or leased by an operator.

2.4 Small-Cell Base Station Transmission Requirements

Deployment of small-cell base stations features different sites and scales. Therefore, small-cell base stations have different transmission requirements from traditional macro base stations in terms of aspects shown in Figure 2-3.

Figure 2-3 Transmission requirements of small-cell base stations

The following gives an overview of these transmission requirements.

- Providing connection

  The first concern for deploying small-cell base stations is to provide connections in different deployment scenarios. The flexible deployment feature enables a small-cell base station to be deployed at different network positions that require different transmission solutions, wired or wireless alike.

  Selection of transmission aggregation node to forward data from a base station is also essential. If wireless transmission is used, existing macro base stations are often used as the transmission aggregation nodes. If wired transmission is used, street cabinets or fixed broadband access points are common transmission aggregation nodes.

  Transmission networks between a small-cell base station and an aggregation node need to support various topologies, such as point-to-point (PtP), point-to-multipoint (PtMP), cascading, tree, and mesh.

  Transmission networks of small-cell base stations need to further provide enough service capacity and small-cell base stations need to accommodate the solutions that can deliver the capacity demands.

- Site adaptability

  Small-cell base stations can be flexibly deployed on billboards, streetlamp posts, and exterior walls of buildings. This calls for flexible power supply modes, compact designs in terms of weight and dimensions, easy installation, automatic antenna alignment, and sound adaptability to ambient environments from small-cell base stations.

- QoS achievability

  Transmission networks of small-cell base stations are required to meet the desired radio performance to ensure high-quality service experience, for example, online video services on mobile phones.

- Simple OM

  An enormous number of small-cell base stations are followed by numerous transmission links, which makes urgent demands on fast, simple, and cost-effective OM solutions.

- Security

  Most of deployment sites of small-cell base station are in untrusted areas. For example, small-cell base stations deployed on streets are easily vulnerable to damages and signal interceptions. Therefore, small-cell base stations have also to provide solutions that meet desired transmission security requirements.

- Clock synchronization

  Small-cell base stations need to implement clock synchronization to ensure good seamless handover performance for users.

  A large number of small-cell base stations are deployed under the coverage of a macro base station and generate interference to existing macro base stations. To address the interference issues, good coordination is required between small-cell and macro base stations. Therefore, strict clock synchronization is also an essential to achieve this goal.

  Clock synchronization is also important to use ICIC and CoMP features supported by LTE-Advanced networks and LTE TDD networks in the near future.

- High reliability

  High-reliability macro networks require five-nine or 99.999% reliability. As specified in *Small Cell Backhaul Requirements* of the Next Generation Mobile Networks Alliance (NGMN), transmission networks for small-cell base stations are required to have three- to four-nine reliability if no macro base station is used to provide backup coverage. If a macro base station is used to provide backup coverage, the reliability should reach to at least two to three nine levels.

  High-reliability transmission can be implemented through link redundancy, resulting in additional transmission costs. Therefore, small-cell base stations have also to achieve a trade-off between reliability and costs.

- Expansion and evolution

  A growing deployment scale of small-cell base stations drives continuous evolutions of the transmission networks to better accommodate network expansion in future and thereby protect existing investment. To achieve this goal, small-cell base stations are required to enable continuous capacity expansion, network topology scalability, and simple expansion management.

Goal of transmission solutions for small-cell base stations: Small-cell base stations have to provide cost effective and flexible transmission solutions while allowing full plays of capacity and performance potentials.

3 Solution

The E2E transmission solution for small-cell base stations includes:

- Last-mile transmission solutions
- Aggregation networking solutions
- Transmission OM solutions
- Transmission security solutions
- Clock synchronization solutions
- Transmission QoS solutions
- Transmission reliability solutions

3.1 Transmission Scenarios

The last mile transmission network and transmission aggregation network are characterized by the deployment site and transmission aggregation node, which are two significant determinants of transmission scenarios of small-cell base stations.

3.1.1 Deployment Places of Small-Cell Base Stations

Deployment places of small-cell base stations: A small-cell base station can be deployed indoors or outdoors.

It is true that small-cell base stations can be deployed in populated urban areas to increase network capacity, in suburban areas to add capacity and coverage, and in rural areas to enlarge coverage. However, transmission scenarios can be categorized by indoor and outdoor deployments due to the following reasons:

- Transmission networks are not available for most outdoor deployment scenarios. Therefore, outdoor deployment is accompanied by fast and cost-effective construction of transmission networks. In addition, outdoor deployment needs to further meet outdoor environment requirements, for example, on temperature, waterproofing, and lightning protections.
- Fixed broadband access networks are often available for indoor deployments. In this situation, an indoor site can reuse them as transmission networks.

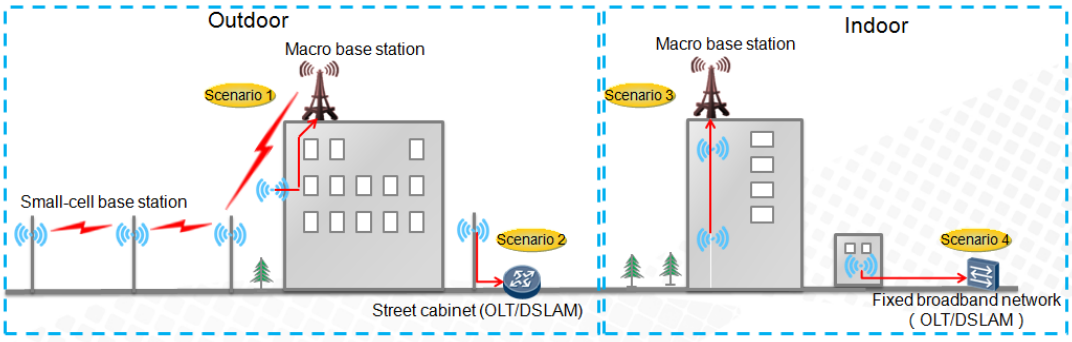
3.1.2 Selection of Transmission Aggregation Nodes

A small-cell base station supports transmission over macro networks and fixed broadband networks. Therefore, both a macro base station site and a fixed broadband access node can be used as a transmission aggregation node for a small-cell base station. Common fixed broadband nodes are, for example, digital subscriber line access multiplexers (DSLAMs) and optical line terminal (OLT).

Table 3-1 Transmission scenarios of a small-cell base station

Scenario	Deployment Site	Transmission aggregation Node	Example
1	Outdoor	Macro base station site	The small-cell base station is deployed on streets or building walls and can be connected in a radio or wired fashion to a nearby macro base station site if no existing transmission networks are available.
2	Outdoor	Access node of a fixed broadband network	The small-cell base station is deployed on streets where existing transmission networks are available. For example, it can be connected to a nearby street cabinet in a wired fashion.
3	Indoor	Macro base station site	The small-cell base station is deployed indoors nearby a macro base station. Therefore, it can be connected to the macro base station site in a wired fashion.
4	Indoor	Access node of a fixed broadband network	The small-cell base station is deployed indoors and no macro base station has been deployed in the nearby areas. In this case, it can be connected to an indoor fixed broadband access network in a wired fashion.

Figure 3-1 Transmission scenarios of a small-cell base station

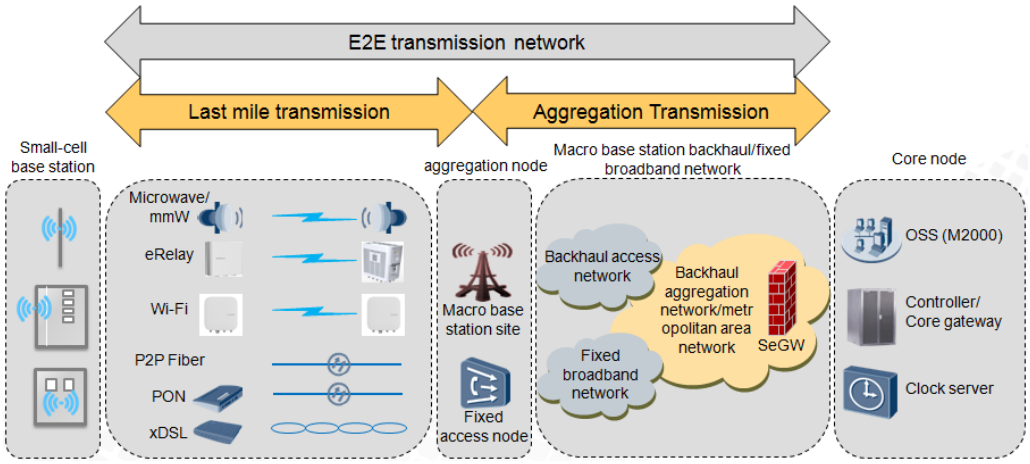


3.2 Solution Overview

To meet the challenge to deploy a small-cell base station in diversified scenarios, Huawei provides flexible and cost-effective transmission solutions for small-cell base stations.

Following is an overview of the transmission solutions for small-cell base stations.

Figure 3-2 E2E transmission networking for small-cell base stations



Similar to a macro base station, the radio access network (RAN) of a small-cell base station is connected to a core node through transmission networks:

- A UMTS small-cell base station is connected to the radio network controller (RNC).
- An LTE small-cell base station is connected to a serving gateway (S-GW) or a mobility management entity (MME).
- Small-cell base stations are also managed through an operation support system (OSS), for example, an M2000.
- In addition, the Wi-Fi function integrated by both UMTS and LTE small-cell base stations allows small-cell base stations to be connected to a Wi-Fi controller.

A transmission network of a small-cell base station consists of a last-mile network and a transmission aggregation network.

The last-mile transmission network connects a small-cell base station and an aggregation site, typically a macro base station, a DSLAM, an OLT, or other access nodes of a fixed broadband network. The last-mile transmission network support diverse access technologies, wired or wireless, to implement deployments in various scenarios.

- If a macro base station is available in the deployment site, the transmission network of a small-cell base station works in wireless or wired mode. Typically, wireless transmission means includes microwave, Millimeter wave, eRelay, Wi-Fi, and wired transmission means PtP fiber, and mini DSLAM or OLT among many others. In this case, the last-mile transmission network can be regarded as an extension of a macro transmission network.

- If an access node for a fixed broadband network, such as a DSLAM or OLT, is available, the small-cell base station connects to the fixed broadband network directly or by using customer premises equipment (CPE) that connects to the small-cell base station. In the former case, the small-cell base station works as a CPE for itself.

The transmission aggregation network connects an aggregation transmission node and a core node, for example, an RNC, an MME, an S-GW, and a Wi-Fi controller. An existing transmission network for macro base stations or a fixed broadband network can be used as a transmission aggregation network.

- If an existing transmission network for macro base stations is used, network connections between the aggregation transmission node and the core node are already available. No change is required on the network connections for deploying a small-cell base station.
- Connections between a fixed broadband network and a core node are often not available. Therefore, if a fixed broadband network is used, efforts are required to connect the fixed broadband network and the core node. This helps integration between transmission mobile aggregation networks for mobile and fixed metropolitan area networks.

The clock server of the macro transmission networks can be used for clock synchronization for transmission networks of a small-cell network. This facilitates handovers between cells.

Either a new security gateway or the original security gateway of the macro transmission networks can be used for transmission security guarantee for transmission networks of a small-cell network.

3.3 Key Solution Features

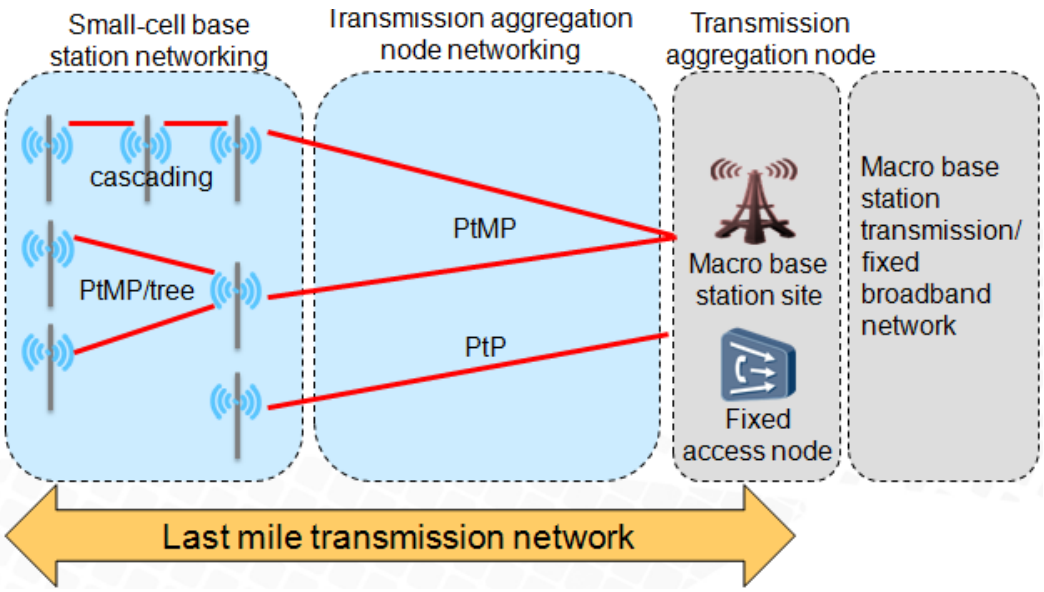
Huawei provides flexible E2E transmission solutions for implementing the deployment of small-cell base stations in diversified scenarios.

3.3.1 Flexible Last-Mile Transmission

Diversified deployment scenarios require various last-mile transmission technologies and network topologies.

Figure 3-3 shows the last-mile transmission networking of a small-cell base station.

Figure 3-3 Last-mile transmission networking of a small-cell base station



As shown in Figure 3-3, the last-mile transmission network covers a small-cell base station and a transmission aggregation node. Therefore, the last-mile transmission networking consists of small-cell base station networking and transmission aggregation node networking.

- Small-cell base station networking:

  It supports cascaded, PtMP, tree, or other types of interoperability among small-cell base stations in different scenarios and continuous network topology evolutions during future network expansions by adding small-cell base stations.
- Transmission aggregation node networking

  It supports PtP and PtMP topologies to connect one or more interconnected small-cell base station groups to a transmission aggregation node.

The last-mile transmission network supports wired transmission, wireless transmission, or mixed use of the two transmission methods.

Huawei provides a last-mile transmission solution that supports various transmission technologies and network topologies, as shown in Table 3-2.

Table 3-2 Last-mile transmission solution for small-cell base stations

Solution		Description	Transmission Features	Application
Wired transmission	xPON	The small-cell station connects to a passive optical network (PON) through an external GPON ONU or a built-in SFP ONU.	Allows kilometers of transmission distance by using optical fiber and a throughput of larger than 1 Gbit/s. Requires an OLT at the CO site and an ONU at the user site to support PtMP networking. Provides reliable QoS performance with zero packet loss and negligible delay	Optical fiber is adequate or can be easily routed. PON backhaul is recommended. PON backhaul is recommended for a full-service operator that has existing PON network resources. Equipment from the same vendor is

Solution		Description	Transmission Features	Application
			Advantage: Existing transmission networks can be reused. Disadvantage: New deployment is cost demanding and interoperability challenging.	recommended for interoperability.
	xDSL	The small-cell base station connects to an xDSL network that uses telephone cables as its transmission medium through an xDSL CPE.	Allows full use of widely available copper cables and supports ADSL2+, VDSL2, and G.SHDSL.bis: ADSL2+: Allows a transmission distance of 6 km and a maximum rate of 1 Mbit/s in the uplink and 24 Mbit/s in the downlink by using a single pair of copper cable. VDSL2: Allows a transmission distance ranging from 300 m to 1000 m and a maximum bidirectional rate of 100 Mbit/s. G.SHDSL.bis: Allows a transmission distance of 4 km and a one-way rate of 20 Mbit/s in the uplink and downlink by using four pairs of copper cables. Supports PtMP and PtP networking. Advantage: Existing transmission networks can be reused. Disadvantage: Copper cables are not mainstream transmission medium and will be replaced by optical fiber. Do not support time synchronization and therefore do not support LTE-advanced. Interoperability is challenging.	Twisted pair cables are widely available in outdoor scenarios and even are deployed to poles. DSL backhaul is recommended. Twisted pair cables are widely for original personal access system (PAS) applications and the small-cell base station is deployed at the PAS site. DSL backhaul is recommended. Twisted pair cables are widely available in indoor scenarios. Indoor deployment of small-cell base station can take advantage of existing DSL lines. Equipment from the same vendor is recommended for interoperability.
	Ethernet or P2P optical fiber	Small-cell base stations support FE/GE interfaces and therefore can connect to Ethernet-capable backhaul equipment, such as an Ethernet switch, through Ethernet	Makes full use of widely available twisted pair cables and Ethernet cables. Allows kilometers of transmission distance by using optical fiber and a throughput of larger than 1 Gbit/s. Supports PtP networking. Provides reliable QoS	Existing optical fiber is available, short transmission distance is needed, and other scenarios where optical fiber resources are adequate and low deployment costs can meet the requirement.

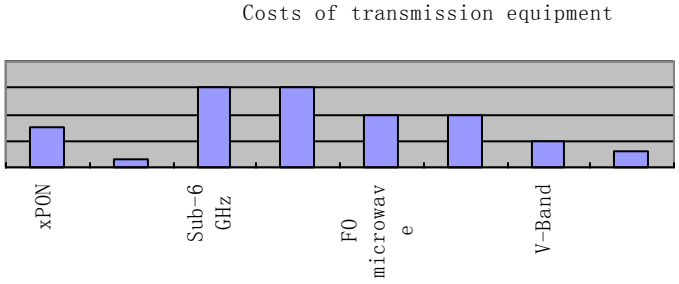
Solution		Description	Transmission Features	Application
		optical fiber or Ethernet cables, depending on the transmission distance between the small-cell base station and its peer device.	performance with zero packet loss and negligible delay Advantage: Existing transmission networks can be used and interoperability can be easily solved. Disadvantage: New deployment requires high costs if optical fiber is used.	
	Cable TV	Small-cell base stations can connect to a cable CPE and use cable TV network as the transmission network.	Supports a maximum rate of 131 Mbit/s in the uplink and 340/440 Mbit/s in the downlink by using Data Over Cable Service Interface Specification 3.0 (DOCSIS 3.0). Supports a maximum rate of 30.72 Mbit/s in the uplink and 42.88/55.616 Mbit/s in the downlink by using DOCSIS 1.0, DOCSIS 1.1, and DOCSIS 2.0. Supports the millisecond level of transmission delay. Supports PtMP networking. Advantage: Existing transmission networks can be used, which requires lower deployment costs. Disadvantage: The transmission delay is large. Do not support time synchronization and therefore do not support LTE-advanced. Interoperability is challenging.	Existing cable TV networks are available. Equipment from the same vendor is recommended for interoperability.
Wireless transmission	Sub-6 GHz	Small-cell base stations support sub-6 GHz (5.4 GHz and 5.8 GHz band) microwave transmission.	Allows a transmission distance of larger than 1 km and a bandwidth of 40 MHz with a throughput of 256 Mbit/s. Supports PtP, PtMP, and NLOS networking. Advantage: Low costs due to unlicensed frequency resources. Fast deployment can be implemented. Disadvantage: The 5 GHz band is unlicensed.	PtP, PtMP, and NLOS networking with requirements of flexible deployment.
	Full-outdoor (FO) microwave	Small-cell base stations connect to FO microwave	Allows a transmission distance of larger than 1 km and a bandwidth of 56 MHz with a throughput of	Suitable for PtP transmission with high

Solution		Description	Transmission Features	Application
	(traditional band)	equipment, which use matured FO microwave technology and allows large capacity and traffic volume without using fixed transmission medium.	800 Mbit/s. Supports PtP and LOS networking. Advantage: The band is licensed and therefore has more available spectrums and higher reliability. Disadvantage: High deployment costs are required due to use of licensed spectrums, and site acquisition is challenging for LOS deployment.	reliability is required.
	LTE TDD backhaul	Small-cell base stations use the LTE TDD-based eRelay solution to construct transmission networks, and the eRelay solution allows NLOS backhaul in PtMP networking at the band of 2.6 GHz and 5 GHz.	Provides a throughput of 80 Mbit/s in the downlink and 28 Mbit/s in the uplink at a bandwidth of 20 MHz. Shares cabinets and M2000 with macro BBUs. Supports PtMP and PtP NLOS networking. Advantage: NLOS deployment can be used, anti-interference performance is sound, and fast deployment is achievable. Disadvantage: Large transmission delay is introduced due to use of LTE TDD technology. Do not support time synchronization and therefore do not support LTE-advanced.	The eRelay solution supports integration with existing macro networks, allows fast deployment, and meets NLOS requirements. This solution can be used as a preferred solution during promotions in existing macro networks built by Huawei and using LTE TDD spectrum. In PtP and PtMP scenarios where interference needs to be avoided.
	Wi-Fi	Small-cell base stations use wireless bridges provided by WLAN APs to implement backhaul transmission.	Allows a transmission distance of within 200 m and a throughput of 80 Mbit/s. Supports PtMP and PtP NLOS networking. Advantage: Low deployment costs are required due to use of unlicensed spectrum, and NLOS and fast deployments are reachable. Disadvantage: Transmission networks are easily vulnerable to interference and therefore performance is not reliable. Do not support time synchronization and therefore do not support LTE-advanced.	PtP, PtMP, and NLOS networking with requirements of flexible deployment. WLAN networks that use equipment from Huawei are available and the AC is shared by the access APs and backhaul APs. Wi-Fi terminals are widely popular and WLAN APs are already deployed at a large scale. Therefore, Wi-Fi backhaul is interference vulnerable. It can be used in limited scenarios.
	V-Band	Transmission	Allows a transmission distance of	LOS deployment

Solution		Description	Transmission Features	Application
		networks of small-cell base stations operate at 60 GHz microwave band in a wireless PtP mode.	within 1 km and a throughput of 400 Mbit/s at a bandwidth of 200 MHz. Supports PtP LOS networking. Advantage: Low deployment costs are required due to use of unlicensed spectrum, and fast deployment is reachable. Disadvantage: Only a short transmission distance (within 1 km) is allowed, and site acquisition is challenging due to LOS deployment.	
	E-Band	Transmission networks of small-cell base stations operate at microwave band ranging from 70 GHz to 90 GHz in a wireless PtP mode.	Allows a transmission distance of 5 km and a throughput of 2.5 Gbit/s at a bandwidth of 500 MHz. Supports PtP LOS networking. Advantage: The band is light-licensed and requires a shorter application period than the traditional bands. Besides, fast deployment is reachable. Disadvantage: High frequency costs are required, and site acquisition is challenging due to short-distance LOS deployment.	LOS deployment
	Satellite	Small-cell base stations use satellite as a relay to implement backhaul transmission, which frees of terrestrial communication restrictions.	Has a round-trip delay of 650 ms. Supports PtMP networking. Advantage: NLOS deployment is allowed. Disadvantage: High deployment costs are required.	This solution is suitable in scenarios where no macro transmission networks and fixed broadband networks are available, for example in remote mountainous areas.

Following are the deployment costs of the transmission solutions in Table 3-2.

Figure 3-4 Cost of transmission equipment



NOTE

The equipment costs for xPON and xDSL are obtained by using quotation in China mainland. If the SFP ONU is used, the equipment cost is about 200 US dollars. The equipment cost for xPON contains only the ONU cost.

The transmission equipment cost for Cable TV and satellite backhaul solutions falls within the responsibility of operators.

If Ethernet or P2P optical fiber transmission is used, small-cell base stations connect to transmission networks through FE/GE interfaces. In this sense, optical fiber cable costs can be neglected.

Equipment cost goes relatively lower if available existing cable resources can be used. If new cables are deployed, the costs vary among regions, as shown in Table 3-3.

Table 3-3 Costs for deploying new cables

24-Core Deployment Costs	Small Cities	Medium Cities	First-tier Cities
China	11,500 $/km	20,000 $/km	36,000 $/km
European developed countries	30,000 $/km	90,000 $/km	120,000 $/km

Highlights of flexible last-mile transmission solution: The last-mile transmission solutions of small-cell base stations support flexible network topologies that allow deployments of small-cell base stations scalable to service development with minimum adjustment on network architecture and equipment, which can greatly reduce costs of deployment, operation, and maintenance.

3.3.2 Aggregation Transmission That Reuses Existing Transmission Resources

Reusing Existing Macro Base Station Transmission as the Transmission aggregation Networks

If a small-cell base station is deployed in a nearby macro base station, the transmission networks of the macro base station can be used as transmission aggregation network of the small-cell base station.

In this case, the small-cell base station can share the clock/phase synchronization and high QoS requirements with the macro base station transmission. The transmission network of the macro base station has to meet the following requirements:

- Transmission networking: The macro base station or cell site gateway (CSG) has at least one idle physical port to carry the aggregation traffic of the small-cell base station.
- Transmission bandwidth: The macro base station transmission has enough bandwidth that meets the traffic volume requirements of the small-cell base station.
- Transmission security: A security gateway is deployed ahead of the controller or mobile gateway to provide encryption for small-cell base station data and protect core site equipment.

This transmission aggregation networking solution provides the following benefits:

- The small-cell base station can use high-QoS transmission for existing macro base stations to perform high-quality wireless services. This helps to achieve consistent and seamless user experience between small-cell and macro base stations.
- Supports smooth evolution and allows coordination between small-cell and macro base stations:

  The LTE-advanced solution uses eICIC and CoMP features that allow sound coordination among cells to increase network capacity and maximize spectrum utilization, which helps to improve network resource utilization and implement network evolution.
- Small-cell base stations share clock/phase synchronization with the macro base stations transmission.
- Allows full use of existing network resources and reduces networking costs.

Reusing Existing Fixed Broadband Networks as the Transmission aggregation Networks

A small-cell base station can use an existing fixed broadband network as the transmission aggregation networks in the following two scenarios:

- A macro base station is not deployed in the nearby area, but a fixed broadband network is available.
- A macro base station is available, but the transmission bandwidth does not meet the requirements.

To be used as a transmission aggregation network of a small-cell base station, the fixed broadband network has to meet the following requirements:

- Transmission networking: The fixed broadband network allows connections to a transmission aggregation network of a macro base station or a mobile network controller/gateway.
- Transmission QoS: The fixed broadband network is shared between mobile users and fixed broadband users. Therefore, it also needs to guarantee QoS for wireless services.
- Time/phase synchronization: The fixed broadband network supports clock/phase synchronization, particularly in indoor scenarios where GPS is often not available. This is because an LTE-TDD or LTE-advanced network requires clock/phase synchronization.

To use a fixed broadband network for transmission aggregation, the transmission solution for small-cell base station needs to meet the following requirements:

- Transmission security: A security gateway is deployed ahead of the controller/gateway to ensure transmission security of wireless services carried over fixed broadband networks that feature low transmission security performance.
- NAT traversal: NAT is widely applied in fixed broadband networks. Therefore, IPSec needs to be used on the small-cell base station to implement NAT traversal.

If fixed broadband networks are used, three sharing modes can be used:

- Small-cell base stations use independent access layer and share resources above the aggregation layer, and dedicated transmission lines are provided for mobile services.

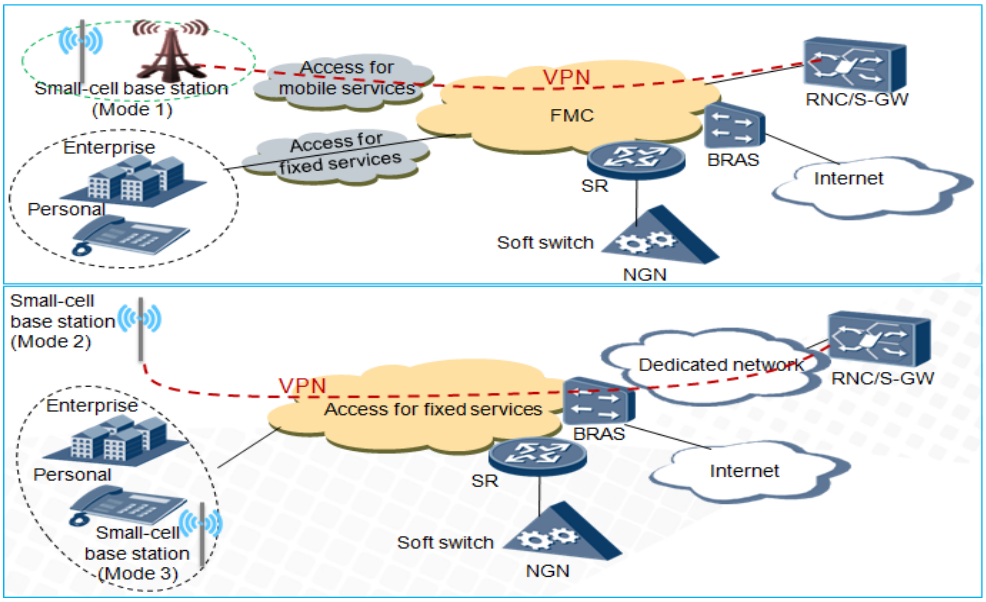
  In this case, the bearer network adopts fixed mobile aggregation (FMC) networking and carries both mobile and fixed services. Dedicated access networks are provided separately for mobile and fixed networks, and dedicated transmission lines are used for mobile services.
- Entire networks are shared by mobile and fixed services, and dedicated transmission lines are provided for mobile services.

  In most scenarios, the QoS requirements of the bearer networks can meet demands of mobile services.
- Entire networks are shared by mobile and fixed services, and dedicated transmission lines are not provided for mobile services.

  In most cases, the QoS requirements are difficult to meet the demands of mobile services if the fixed network is experiencing congestion.

Of the three sharing modes, the third one is not recommended because no dedicated transmission lines are provided for mobile services.

Figure 3-5 Small-cell base stations using fixed broadband networks as the transmission aggregation networks



Using existing fixed broadband networks as the transmission aggregation networks helps reduce networking costs by making full use of fixed broadband network resources.

3.3.3 Flexible and Unified OM

Massive small-cell base stations on a mobile network need numerous transmission connections, and the number of transmission connections is bound to increase along with future network expansions. This makes network management a complex task.

The last-mile transmission networks require use and management of various transmission technologies, which consequently requires various management devices and systems. This further aggregates the network management complexity.

To address network management issues, simple and integrated management solutions are urgently required to perform centralized network control and management.

Table 3-4 shows the simple and integrated network management solutions available for managing transmission of small-cell base stations:

Table 3-4 Network management solutions for small-cell base stations

Solution	Description	Benefits
Single OSS on the entire network	The U2000 of Huawei can be used for unified operation and management of E2E transmission networks (including last-mile networks and transmission aggregation networks) in the following two scenarios: The last-mile transmission networks adopt equipment from Huawei, and the transmission networks of macro base stations of Huawei are used as transmission aggregation networks. The last-mile transmission networks adopt equipment from Huawei, and the fixed broadband networks that use equipment from Huawei are used as transmission aggregation networks.	The networking is simple and allows unified operation and management using single OSS system. Besides, network delivery time can also be shortened. Low cost: This solution allows smooth evolution and expansion of the existing networks and helps reduce the OPEX.
Single OSS on a greater SingleRAN	If the last-mile transmission network adopts the eRelay or microwave transmission equipment from Huawei, the M2000 can be used for unified operation and management for the RAN and the last-mile networks of small-cell base stations.	Simple networking: The SingleRAN OSS is used for unified management of the RAN. Therefore, a greater SingleRAN network that consists of small-cell base stations, transmission networks of small-cell base stations, and macro base stations of Huawei is available regardless of the vendors of the transmission networks of macro base stations and fixed broadband networks. Low cost: Newly added small-cell base stations produce minimized impact on the exiting RAN, which helps shorten delivery time and

Solution	Description	Benefits
		reduce the OPEX.
Single OSS for Wi-Fi access and transmission	If Wi-Fi transmission network built by Huawei is used, the wSight of Huawei from the WLAN is required for unified operation and management.	Existing Wi-Fi networks supports smooth expansion, which helps lower deployment costs and OPEX while weakening interference and quickening delivery.

If other network management solutions are used, interoperability with equipment from other vendors and dedicated network management are required. As a result, operators have to use OSS systems from different vendors to handle concurrent maintenance and management, which pushes up operating expenses. Therefore, other network management solutions for deploying small-cell base station are not recommended.

Small-cell base stations also support E2E performance detection and fault detection:

- IEEE 802.3ah and IEEE 802.1ag for the data link layer:

  The IEEE 802.3ah is OAM protocol for E2E Ethernet links and supports peer OAM capability discovery, remote loopback, and link event notification.

  The IEEE 802.1ag is an E2E Ethernet connectivity fault management protocol and supports connectivity detection, loopback, and Ethernet link trace.
- IPPM, BFD, ICMP Ping, and Trace route for the network layer

  The IPPM is a performance detection protocol for IP networks and supports E2E QoS detection and measurement of latency, jitter, and packet loss rate. It can be used to check transmission link quality and therefore provide reference to operators for network planning, deployment, operation, and upgrade.

  The BFD is a fault detection protocol for bidirectional paths between two forwarding entities. It is used to check the connectivity of the physical or logical link between two systems. The BFD can work at layer 2 or higher layers. The small-cell base station implements the BFD mechanism through the UDP.

  The Internet Control Message Protocol (ICMP) ping and the traceroute are used to detect connectivity and locate faults at the IP layer.

Highlights of flexible and unified OM solution: Flexible and unified OM facilitates deployments in different transmission scenarios. Unified and consistent network management helps reduce operating expense and allows cost-effective commercial deployment solutions for small-cell base stations. Besides, small-cell base stations support E2E performance detection and fault detection, which can further reduce operating expenses.

3.3.4 E2E Transmission Security

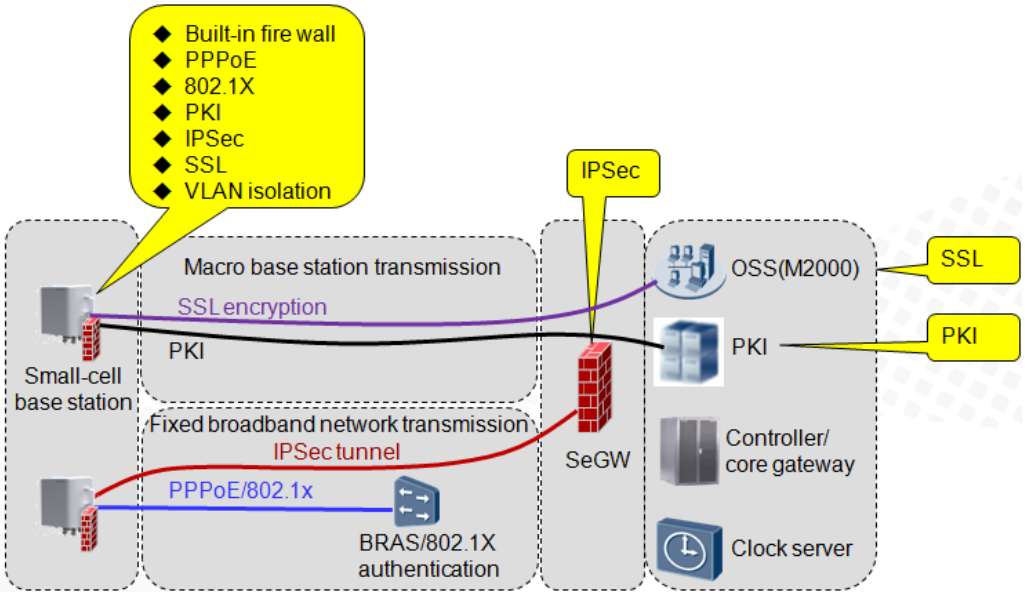
Small-cell base stations are mostly deployed in untrusted scenarios and use fixed broadband networks as transmission aggregation networks. In addition, they use Ethernet and IP interfaces that are easily subject to signal leakages. Therefore, small-cell base stations require sound transmission security solutions.

The E2E transmission security solution of Huawei ensures the transmission security of small-cell base stations at both equipment and network levels.

Table 3-5 Transmission security solution for small-cell base stations

Level	Solutions	Benefits
Equipment level	Supporting built-in firewalls	Prevents the equipment from attacks through its transmission interfaces.
Network level	Supporting PPPoE Authentication Supporting 802.1X Authentication Supporting PKI Supporting VLAN isolation Supporting IPSec Supporting SSL	Prevents unauthorized accesses. Ensures data security on both user plane and control plane.

Figure 3-6 Ensuring transmission security of small-cell base stations



Built-in firewall: Small-cell base stations support built-in firewall to filter out invalid packets to prevent unauthorized accesses.

PPPoE authentication: The PPPoE protocol is an access protocol introduced by the Internet Engineering Task Force to carry the Point-to-Point Protocol (PPP) over the Ethernet. It works between the BRAS and small-cell base stations to ensure authorized access of small-cell base station to the fixed broadband network.

802.1X authentication: The IEEE 802.1X is a port-based network access control protocol. It is used to ensure network security by protecting network interfaces and preventing unauthorized accesses to networks. This protocol works between an 802.1X authentication enabled device (such as a switch and BRAS) and the small-cell base station.

PKI, short for public key infrastructure, uses asymmetric key algorithms to ensure information security. It provides networks with the key and digital certificate management needed to implement password services through encryption and digital signature. The PKI

system and interfaces are compatible with X.509 and 3GPP TS.33.310. The Certificate Management Protocol version 2 (CMPv2) is used to exchange information about certificate application, issue, and upgrade to implement certificate management between small-cell base stations and PKI systems.

VLAN isolation: The transmission interfaces of small-cell base stations support VLAN tags. Therefore, a virtual local area network (VLAN) can be used to isolate traffic from small-cell base stations and other networks.

IPSec is a security architecture introduced by the IETF to provide E2E security protection for data transmission in an untrusted network, such as the Internet, including privacy protection, integrity protection, origin authentication protection, and replay attack protection. IPSec is located at the IP layer of the TCP/IP protocol stack and works between a security gateway and small-cell base stations to provide transparent E2E security services to upper-layer applications.

SSL, short for Security Socket Layer, is introduced by Netscape to provide authentication, privacy protection, and integrity protection between two communication applications. Transport Layer Security (TSL) is an evolved version of SSL, and the latest TSL version is TLSv1.2. SSL works between the M2000 and small-cell base stations or controllers to ensure data transmission security for OM channels.

Highlights of E2E transmission security solution: Small-cell base stations provide a whole set of transmission security solutions at both equipment and network levels to ensure equipment security, access security, and data security.

3.3.5 Flexible E2E Clock Synchronization

To implement mobile services and functions, small-cell base stations require clock synchronization, including frequency synchronization and time synchronization.

On a WCDMA and LTE-FDD network, frequency synchronization needs to be ensured on all the nodes to carry basic services.

High-end services, such as multimedia broadcast multicast services (MBMS) and evolved multimedia broadcast multicast service (eMBMS), also require time frequency on a WCDMA and LTE-FDD network. In addition, an LTE-TDD or LTE-advanced network, and eICIC and CoMP features are dependent on strict time synchronization to implement roaming and handovers of mobile services.

Table 3-6 lists the clock synchronization requirements of small-cell base stations on different networks and for different features.

Table 3-6 Clock synchronization requirements for small-cell base stations

Application		Frequency Synchronization	Time Synchronization
RAT	WCDMA	**50 ppb**	**None**
	LTE FDD	**50 ppb**	**None**
	LTE TDD	**50 ppb**	**1.5 us**
Features	MBMS/eMBMS	**None**	**1.5 us**
	eICIC	**None**	**1.5 us**
	CoMP	**None**	**1.5 us**

Small-cell base stations of Huawei support the clock synchronization schemes listed in Table 3-7.

Table 3-7 Clock synchronization schemes on small-cell base stations

Type	Scheme	Benefits
Frequency synchronization	• IEEE 1588v2 • SyncE • RGPS (LTE)	Existing clock servers for transmission networks of macro base stations or clock signals provided by macro base stations can be used, which helps reduce transmission costs. Synchronous Ethernet (SyncE) and IEEE 1588v2 frequency synchronization apply to all scenarios without the help of GPS. This is particularly useful in indoor scenarios where GPS is not available. A remote global positioning system (RGPS) for LTE networks is not dependent on transmission networks. This feature can be used in scenarios where IEEE 1588v2 time synchronization is not available.
Time synchronization	• IEEE 1588v2 • RGPS (LTE)	

IEEE 1588v2 is a precision time protocol (PTP) and supports both frequency and time synchronization.

If IEEE 1588v2 is used on a frequency synchronization networking, intermediate transmission equipment is required to support Layer 3 unicast packet forwarding regardless of the support of IEEE 1588v2.

If IEEE 1588v2 is used on a time synchronization networking, the BC function defined in IEEE 1588v2 is required on all intermediate equipment of the data bearer network.

SyncE provides frequency synchronization at the physical layer of an Ethernet network. On a SyncE network, time synchronized signals are not available. Therefore, SyncE is applicable only to time synchronization scenarios.

RGPS supports both frequency synchronization and time synchronization. In this clock synchronization scheme, the remote GPS (RGPS) unit provides clock signals to small-cell base stations. Therefore, to use this scheme, the small-cell base station needs to be equipped with an RGPS unit.

Clock synchronization of small-cell base stations can be implemented by the time/frequency synchronization servers deployed for existing mobile transmission networks.

Highlights of flexible e2e clock synchronization solution: Small-cell base stations support different clock synchronization schemes and therefore can be applied in various scenarios. With these schemes, small-cell base stations can use time/frequency synchronization servers of the existing mobile transmission networks to implement time and frequency synchronization. They can also meet clock synchronization requirements for future network evolutions.

3.3.6 E2E Transmission QoS Management

A small-cell base station does not only carry Internet services. It also carries services of high QoS requirements, such as VoIP and online video services. Therefore, QoS management is required for the small-cell base station.

Small-cell base stations of Huawei support the following QoS management schemes:

- Small-cell base stations map different types of services to different priorities (defined using DSCP and IEEE 8021.P) of the transmission layer. The transmission network equipment performs QoS scheduling for services according to QoS tags to ensure the QoS at the transport layer.
- Small-cell base stations and network controllers perform flow control in response to changes in transmission network bandwidth to implement dynamic management of transmission bandwidth. This helps maximize utilization of transmission bandwidth resources and reduce chances of service KPI deterioration caused by congestion of transmission networks.

Highlights of E2E transmission QoS management solution:

Small-cell base stations of Huawei support a whole set of E2E transmission QoS management schemes that can allow better service quality management and achieve consistent user experience.

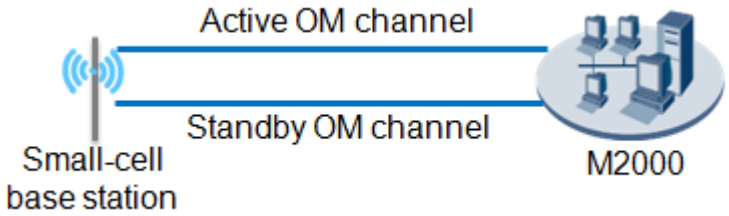
3.3.7 E2E Transmission Reliability

Small-cell base stations of Huawei support the E2E transmission reliability solutions:

- Active and standby OM channel on the management plane

  Active and standby OM channels are used between the M2000 and small-cell base stations to enhance OM channel reliability. Active OM channels have higher priorities than standby OM channels. The M2000 preferentially uses the active OM channel to establish a connection to a small-cell base station. If the active OM channel is experiencing faults, the M2000 will choose to establish a connection to a small-cell base station through the standby OM channel. If the standby OM channel is used, the M2000 maintains the connection even after the faults of the active OM channel are cleared. The M2000 will attempt to establish a connection to the small-cell base station using the active OM channels when the standby OM channel becomes faulty.

Figure 3-7 Active and standby OM channels of a small-cell base station

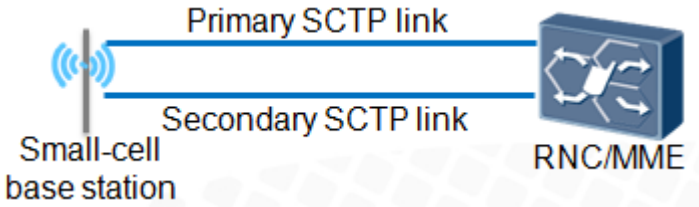


- Active and standby SCTP links and primary and secondary IPSec channels on the user plane and control plane

  In stream control transmission protocol (SCTP) multi-homing, an SCTP association is a logical channel that links two SCTP endpoints. A redundant transmission path is used between two SCTP endpoints. Therefore, an SCTP association has one primary path and

one secondary path. Normally, the primary SCTP path stays active. If the primary SCTP path is faulty, the secondary SCTP turns active to take over the primary one. This helps improve fault tolerance performance of small-cell base stations.

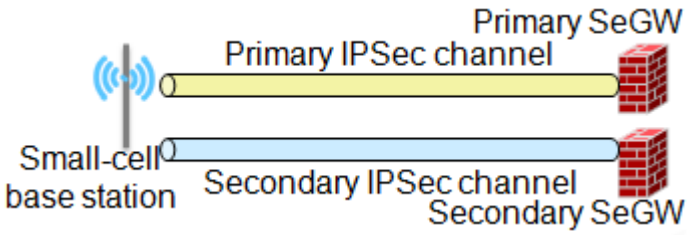
Figure 3-8 SCTP multi-homing for a small-cell base station



Primary and secondary IPSec channels: In IPsec networking scenarios, a small-cell base station connects to the primary and secondary security gateways (SeGWs) through the primary and secondary IPSec tunnels respectively, which operate in hot backup mode. This ensures reliability of the IPSec tunnels. IKE tunnels and IPsec tunnels are negotiated respectively between a small-cell base station and primary and secondary gateways. In normal cases, IPSec traffic is transmitted through the primary IPSec tunnel. If the primary IPSec tunnel is faulty due to, for example, a link failure, services automatically switch over to the secondary IPSec tunnel. If the secondary IPSec tunnel is used, service traffic is retained on the secondary IPSec tunnel even after the primary IPSec tunnel returns normal.

If primary and secondary IPsec channels are deployed, BFD needs to be enabled on the small-cell base station to check the connectivity between the eNodeB and gateways.

Figure 3-9 Primary and secondary IPSec tunnels for a small-cell base station



Highlights of E2E transmission reliability solutions:

Small-cell base stations of Huawei support a complete set of E2E transmission reliability solutions on the management plane, user plane, and control plane. This helps enhance service reliability and improve service experiences.

3.4 Solution Key Products

The E2E transmission solution of Huawei involves the key products listed in Table 3-8.

Table 3-8 Key products for the E2E transmission solution

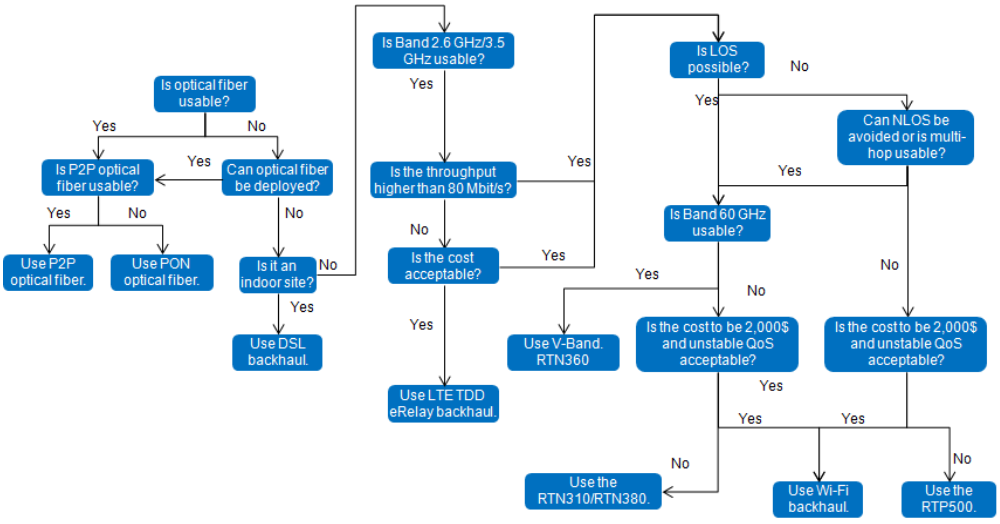
Category	Product	Highlight
OSS	U2000/M2000/wSight	The U2000 provides management for the transmission aggregation networks of small-cell base stations. The M2000 provides unified management for the RAN, eRelay systems, and microwave transmission equipment of Huawei. The wSight provides management for Wi-Fi systems.
SeGW	E8000E-X	This product has been widely used in commercial networks.
IP Clock Server	IP CLOCK 1000	This product has been widely used in commercial networks.

3.5 Solution Application Principle

3.5.1 Principle of Selecting Late-Mile Transmission Networks

Figure 3-10 shows the overall procedures for choosing an appropriate last-mile transmission solution for a small-cell base station

Figure 3-10 Procedures for choosing an appropriate last-mile transmission solution for a small-cell base station



The principle of choosing the last-mile transmission solution for small-cell base stations is as follows:

- Existing wired transmission resources are the first choice for backhaul transmission of small-cell base stations.
- If existing wired transmission resources cannot meet site requirements, new wired transmission resources are preferred.
- If wired transmission cannot be used, wireless transmission is used for backhaul of small-cell base stations.

Table 3-9 Recommended wired transmission for backhaul of small-cell base stations

Recommended Level	Scenario	Recommended Solution	Delivery Status
First choice	P2P Ethernet backhaul and a macro base station as the transmission aggregation network	Small-cell base stations provide FE/GE electrical ports and allow transmission over optical fiber.	Ready
Second choice	PON backhaul Interoperability of PON systems from different vendors needs to be considered.	The BTS3902E and BTS3203E support built-in SFP ONU and can therefore provide a PON interfere for uplink transmission.	Ready
		The BTS3202E and 3803E have PON interfaces. The DOCK 2 or MS5694S from the Access Network Product Line is used. Therefore, small-cell base stations can provide PON interferences for uplink transmission. In this sense, The DOCK 1 is not needed.	January, 2014
	DSL backhaul	Modem is provided by the operator.	Ready
		The BTS3202E and 3803E have VDSL interfaces. The DOCK 2 or MS5694S from the Access Network Product Line is used. Therefore, small-cell base stations can provide VDSL interferences for uplink transmission. In this sense, The DOCK 1 is not needed.	2013 Q3 (TR3)

NOTE

The DOCK 1 is a site transmission device from the Wireless Product Line and is mandatory for the BTW3803E and BTS3203E. If the DOCK 1 cannot meet the requirement, the DOCK 2 that allows small-cell base stations to use PON or VDSL interfaces for uplink transmission is recommended. For details about the product capability and delivery status of the DOCK, DOCK2, and MA5964S, see Table 3-10.

Table 3-10 Product capability and delivery status of the DOCK, DOCK2, and MA5964S

	Capability	Delivery Status
DOCK	One optical port and three electrical ports	Ready
DOCK2	Three electrical ports, and PON or VDSL ports	January, 2013 (GA)
ATN 905 (or named as CBU/MA5964S)	One optical port and two electrical ports, plus one electrical or optical port	Ready

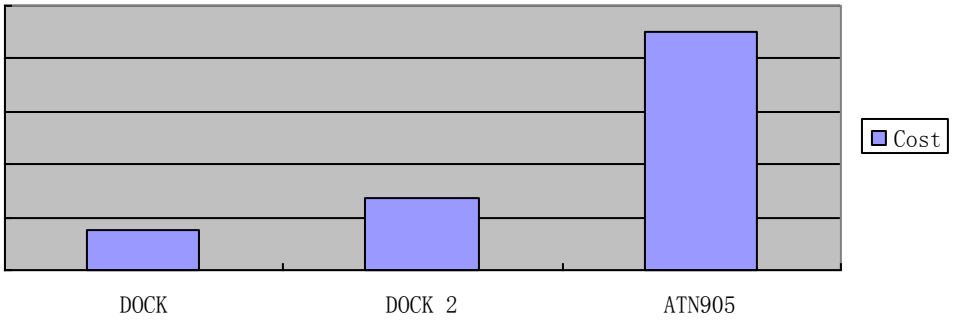


Table 3-11 Recommended wired transmission for backhaul of small-cell base stations based on maximized cost-performance ratio

Scenario	Throughput		Transmission Distance (< 100 m)	Transmission Distance (< 500 m)
LOS transmission	20 Mbit/s	UMTS: DC HSDPA 2x2 64QAM or LTE: 10 MHz 2x2	First choice: Wi-Fi Second choice: V-Band [2014 Q2]	First choice: Wi-Fi Second choice: V-Band [2014 Q2]
	50 Mbit/s	LTE: 20 MHz 2x2		
	100 Mbit/s	UMTS: DC HSDPA 2x2 64QAM and LTE: 20 MHz 2x2		First choice: V-Band [2014 Q2] Second choice: RTN310 [Ready]
	200 Mbit/s	UMTS: DC HSDPA 2x2 64QAM and LTE: 20 MHz 2x2 3-level cascading connection	First choice: V-Band [2014 Q2] Second choice: RTN310 [Ready]	
NLOS transmission	20 Mbit/s	UMTS: DC HSDPA 2x2 64QAM or LTE: 10 MHz 2x2	First choice: TDD eRelay [Ready] Second choice: Wi-Fi	
	50 Mbit/s	LTE: 20 MHz 2x2		
	100 Mbit/s	UMTS: DC HSDPA 2x2 64QAM and LTE: 20 MHz	PTP500 [Ready]	

Scenario	Throughput		Transmission Distance (< 100 m)	Transmission Distance (< 500 m)
		2x2	Second choice: V-Band [2014 Q2]	
	200 Mbit/s	UMTS: DC HSDPA 2x2 64QAM and LTE: 20 MHz 2x2 3-level cascading connection		

NOTE

If the existing WLAN network is built by Huawei, the WA251DT-NE from Huawei is recommended for backhaul transmission of small-cell base stations, WA251DT-NE of Huawei is recommended.

If the existing WLAN network is built by other vendors, it is recommended that the Ruckus 7731 is used for backhaul transmission of small-cell base stations. In this case, the Ruckus 7731 can be either provided by the operator or purchased by the regional divisions, but the network management system needs to be provided by the operator.

If the preceding backhaul transmission solutions cannot meet site requirements, contact R&D of Huawei for help.

Table 3-12 Backhaul products for small-cell base stations

Last-mile Transmission	Huawei Product	Product Capability
Sub-6 GHz	PTP500 [Ready]	NLOS and P2P
FO microwave (Traditional band)	RTN 310 [Ready]	LOS and P2P
TDD BH	TDD eRelay [Ready]	NLOS and P2MP (1:6)
WiFi	W251DT [2013 Q3]	NLOS and P2MP (1:6)
V-Band	RTN360 [2014 Q2]	LOS and P2P
E-Band	RTN 380 [Ready]	LOS and P2P

3.5.2 Principle of Selecting Transmission aggregation Nodes

By definition of the 3GPP, a heterogeneous network (HetNet) means that low-powered nodes, for example, small-cell base stations, are deployed within the coverage area of a macro base station. Therefore, small-cell base stations are generally deployed nearby a macro base station.

A transmission aggregation node for a small-cell base station can be a macro base station site or an access node of a fixed broadband network, such as DSLAM and OLT.

According to Small Cell Backhaul Requirement of the NGMN, the backhaul transmission for small-cell base stations should meet the following requirements:

- If a small-cell base station is deployed nearby a macro base station, the macro base station site is preferred as the transmission aggregation node.

- If a small-cell base station is not deployed nearby a macro base station and fixed transmission resources are available, the fixed broadband network is preferred as the transmission aggregation node.

If the macro base station site cannot provide sufficient transmission bandwidth for aggregation transmission of the small-cell base station, the fixed broadband network can also be as the transmission aggregation node.

Table 3-13 Comparison between different transmission aggregation nodes of a small-cell base station

Comparison Point	Macro Base Station Site	Access Nodes of Fixed Broadband Network
Advantage	Uses high-QoS transmission for existing macro base stations site to achieve consistent and seamless user experience. Supports smooth evolution and allows coordination between small-cell and macro base stations: The LTE-advanced solution uses eICIC and CoMP features that allow sound coordination among cells to increase network capacity and maximize spectrum utilization, which helps to improve network resource utilization and implement network evolution. Shares clock synchronization with the macro base stations transmission. Meets deployment requirements of most operators. A survey about small cell mobile backhaul equipment by Infonetics Research in 2013 has shown that over 80% of operators tend to use a macro site as transmission aggregation nodes for small-cell base stations.	Allows full use of existing network resources and reduces networking costs.
Disadvantage	Requires huge transmission capacity from the macro base station.	Hampers network evolutions and coordination between small-cell and macro base stations. The LTE-TDD networks and LTE-advanced networks, as well as eMBMS services need strict time synchronization that is not supported by existing fixed broadband network. To support future wireless network evolution, the entire, or at least the access section of the fixed broadband network, needs to be upgraded. This increases network evolution costs. If GPS is not available in indoor scenarios and the fixed broadband network does not support time synchronization, a macro base station as a transmission aggregation node is recommended.

As a summary, during selection of a transmission aggregation node, considerations need to be made regarding how to achieve maximum use of existing network resources while allowing convenient evolution to LTE and LTE-advanced networks

4 Experience

Huawei's transmission solution for small-cell base stations has by now been put into practice by a multiple number of operators. The E2E transmission solution for small-cell base station has been deployed in multiple commercial networks of China Unicom, Vodafone, and Telus among many other operators and won popular recognition from these operators.

Table 4-1 shows some cases of Huawei's transmission solution for small-cell base stations.

Table 4-1 Cases of the transmission solution for small-cell base stations

Operator	Transmission Solution
China Unicom	The last-mile transmission is implemented through optical Ethernet and a dedicated bearer network is built for backhaul transmission of the small-cell base stations.
LGU+ of ROK	The last-mile transmission is implemented through Ethernet passive optical network (EPON) and a dedicated bearer network is built for backhaul transmission of the small-cell base stations.
IUSACELL of Mexico	The last-mile transmission is implemented through gigabit-capable passive optical network (GPON) and a dedicated bearer network is built for backhaul transmission of the small-cell base stations.
VDF of Spain	The last-mile transmission is implemented through TDD BH eRelay solution and a dedicated bearer network is built for backhaul transmission of the small-cell base stations.
Telus of Canada	The last-mile transmission is implemented through optical Ethernet and a dedicated bearer network is built for backhaul transmission of the small-cell base stations.

5 Conclusion

With a growing number of small-cell base stations followed by aggressive deployments to meet traffic demands for intelligent terminals and heavy-traffic services, as well as due to different deployment sites from macro base station, small-cell base stations are facing enormous challenges in the aspect of transmission and diverse deployment requirements.

To meet these challenges for deploying small-cell base stations, Huawei provides a flexible and cost-effective transmission solution to ensure reliable network functions and sound network performance. The transmission solution for small-cell base stations provides the following benefits:

- Provides flexible last-mile transmission solutions suitable for different technologies and network topologies, which meets requirements of diverse deployments and network evolution.
- Allows reuse of existing transmission resources as the transmission aggregation networks to reduce deployment costs.
- Allows flexible and unified OM in different transmission scenarios and supports E2E performance detection and fault detection, which allows cost-effective deployment and reduced operating expense of small-cell base stations.
- Provides a complete set of transmission security solutions at both equipment and network levels to ensure equipment security, access security, and data security.
- Supports flexible E2E clock synchronization schemes and allows use of existing time/frequency synchronization servers to implement time and frequency synchronization, which meets diverse deployment requirements and facilitates future network evolutions.
- Supports a whole set of E2E transmission QoS management schemes that allow better service quality management and consistent user experience.
- Supports transmission reliability schemes on the management plane, user plane, and control plane, which helps enhance service reliability and improve service experiences.

Huawei's transmission solution for small-cell base stations has shown sound effectiveness through applications by a multiple number of operators on their networks.

A Acronyms and Abbreviations

Acronyms and abbreviations	Full Name
3GPP	3rd Generation Partnership Project
ADSL2	Asymmetric Digital Subscriber Line 2 plus
BC	Boundary Clock
BFD	Bidirectional Forwarding Detection
BYOD	Bring Your Own Device
CoMP	Coordinated multi-point transmission/reception technology
CPE	Customer Premises Equipment
DSCP	Differentiated Services Code Point
DSLAM	Digital Subscriber Line Access Multiplexer
eICIC	enhanced ICIC
eMBMS	evolved Multimedia Broadcast Multicast Service
FMC	Fixed Mobile Aggregation
FO	Full Outdoor
GPON	Gigabit-capable Passive Optical Network
GPS	Global Positioning System
HetNet	Heterogeneous Network
IPPM	IP Performance Monitoring
IPSec	Internet Protocol Security
ICIC	Inter-Cell Interference Coordination
KPI	Key Performance Indicator

Acronyms and abbreviations	Full Name
LOS	Line of Sight
LTE	Long Term Evolution
LTE-A	Long Term Evolution Advanced
MBMS	Multimedia Broadcast Multicast Service
MME	Mobility Management Entity
NAT	Network Address Translation
NGMN	Next Generation Mobile Networks Alliance
NLOS	Non Line of Sight
OLT	Optical Line Terminal
OM	Operations Management
ONU	Optical Network Unit
OPEX	Operating Expense
OSS	Operations Support System
PKI	Public Key Infrastructure
PPPoE	Point-to-Point Protocol over Ethernet
PtP	Point to Point
PtMP	Point-to-Multipoint
QoS	Quality of Service
RNC	Radio Network Controller
SCTP	Stream Control Transmission Protocol
SFP	Small Form-factor Pluggable
SeGW	Security Gateway
SGW	Serving Gateway
SSL	Secure Sockets Layer
SyncE	Synchronous Ethernet
xDSL	Digital Subscriber Line
VDSL2	Very-high-speed Digital Subscriber Line 2
DOCSIS	Data Over Cable Service Interface Specification