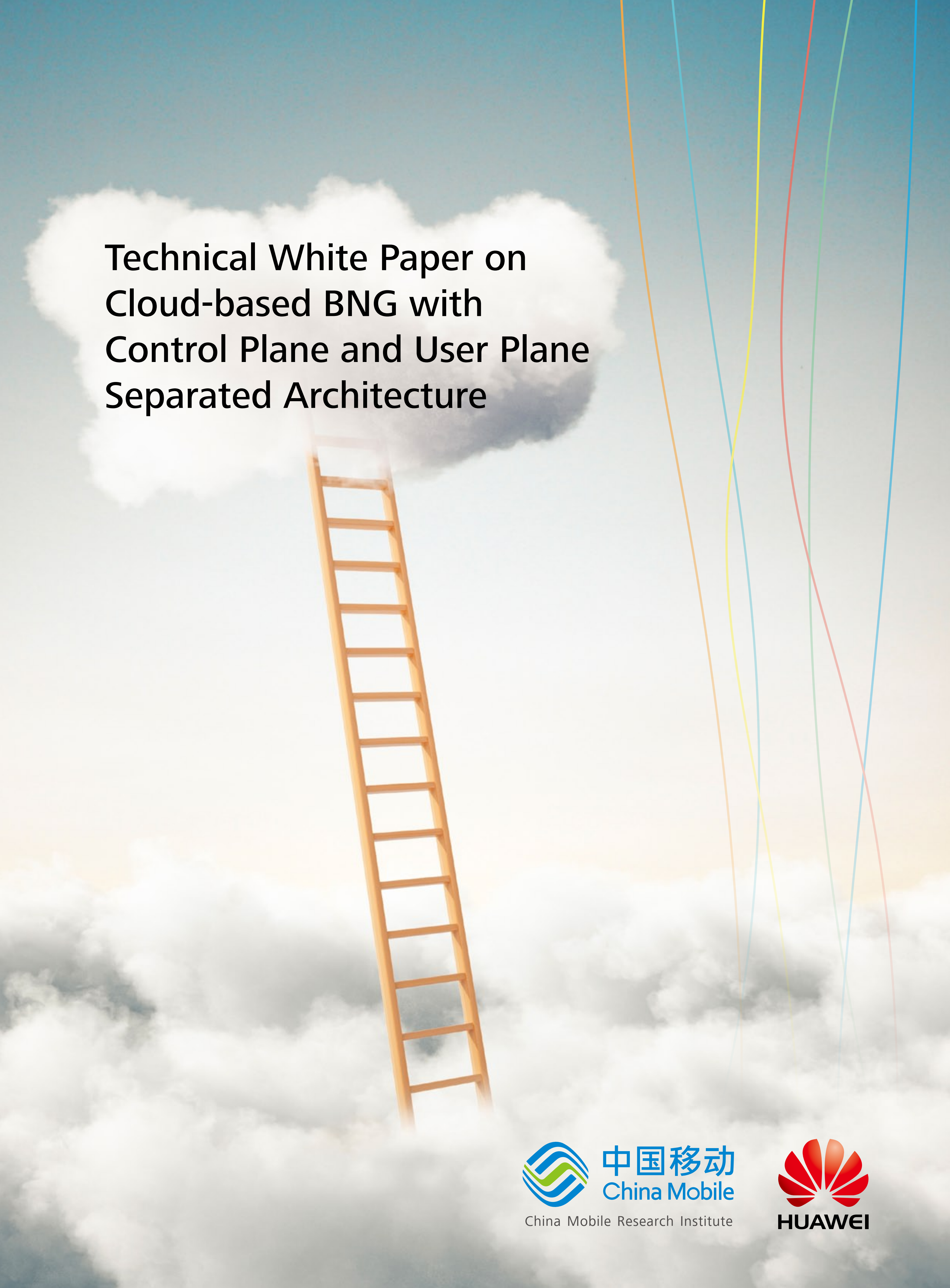
Technical White Paper on Cloud-based BNG with Control Plane and User Plane Separated Architecture



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Abstract:

This paper describes the background of and challenges faced in metro network. It also describes the cloud-based BNG with control plane and user plane(C/U) separated architecture and the future evolution of the cloud-based metro network architecture.

Keywords:

metro network, cloud-based architecture, C/U separation, CloudMetro, BNG, SDN, NFV, TIC.

1 About This White Paper

The rapid development of new services such as 4K and IoT and increased number of home broadband service users present daunting challenges for BNGs, which are core components for metro network home broadband access:

» **Low resource utilization:** The traditional BNG acts as both a gateway for user access authentication and accounting and an IP network's Layer 3 edge. The mutually affecting nature of the tightly coupled control and forwarding planes makes it difficult to achieve the maximum performance of either plane.

» **Complex management and maintenance:** Due to the large number of traditional BNGs, a network must have each device configured one at a time when deploying global service policies. As the network expands and new services are introduced, this deployment mode will cease to be feasible as it is unable to manage services effectively and rectify faults rapidly.

» **Slow service provisioning:** The coupling of control and data planes, in addition to a distributed network control mechanism, means that any new technology has to rely heavily on the existing network devices. Therefore, multiple devices have to be synchronized and updated. This results in long service TTM, which greatly hinders the network's evolutionary development.

To address these challenges, cloud-based BNG with C/U separated architecture is introduced. This white paper describes this C/U separated BNG architecture and the related technical requirements. It also describes the future evolution of cloud-based metro networks. This white paper, jointly developed by China Mobile Research Institute and Huawei Technologies Co., Ltd, is expected to promote the maturation of the cloud-based BNG with C/U separated architecture and accelerate the commercialization of cloud-based metro networks.

2 General Network Planning

China Mobile promotes a future architecture with TIC (Telecom Integrated cloud) as basic unit focusing on content and traffic, instead of traditional voice and data.. This architecture mainly comprises core TIC layer and edge TIC layer.

» **Core TIC layer:** mainly responsible for control, management, and scheduling functions and carries control-plane NE, centralized media-plane NE, CDN device, and backbone network traffic. Typical NEs of this layer are BNG-CPs.

» Edge TIC layer: oriented towards the three major media planes and is mainly responsible for terminating media traffic. Typical NEs of this layer are BNG-UPs.

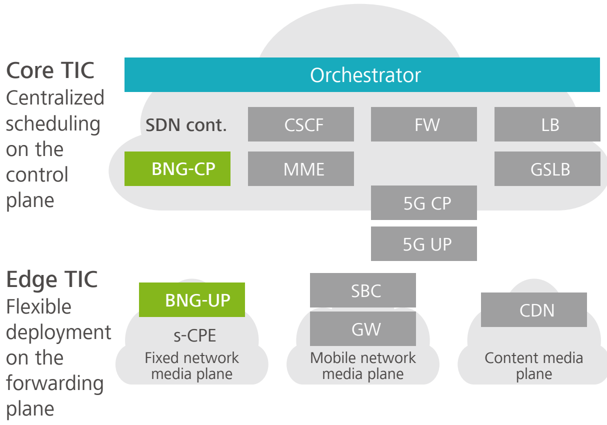
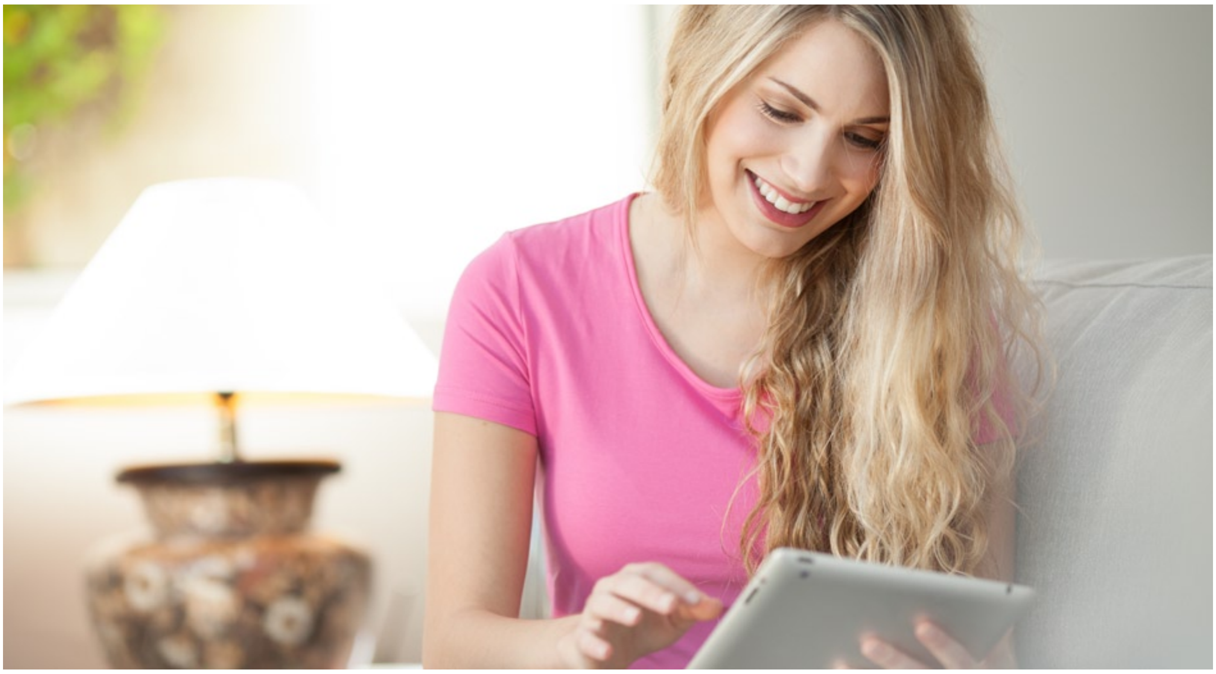


Figure 2-1 New network architecture

In this new network architecture, BNGs, including BNG-CPs and BNG-UPs, are core components for fixed broadband services. BNG-CPs are deployed at the core TIC layer and BNG-UPs at the edge TIC layer.



3 Cloud-based BNG with C/U separated architecture

3.1 BNG Architecture for Traditional Metro Networks

Figure 3-1 shows the BNG architecture for traditional metro networks.

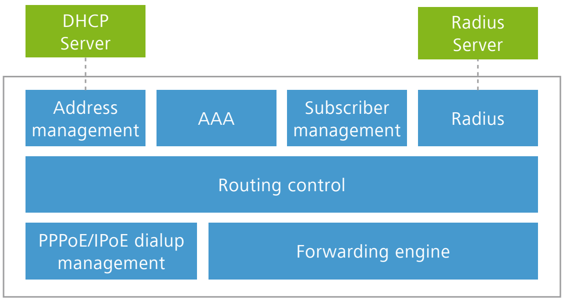


Figure 3-1 BNG architecture for traditional metro networks

The traditional BNG incorporates user access management functions in addition to router functions. Address management supports requesting IP addresses from the remote address pool through DHCP, allocating IP addresses to terminals, and managing terminal IP addresses. AAA supports user authentication, authorization, and accounting. User management is to generate user forwarding entries based on user access policies, such as QoS, access modes, and charging modes, and deliver these entries to the forwarding engine. RADIUS supports the obtaining of user access policies from the RADIUS server. A BNG typically supports PPPoE and IPoE access modes. To enhance user online capacity, the forwarding plane provides PPPoE and IPoE dialup management through multiple CPUs and takes responsibility for state machines that handle these two dialup protocols.

3.2 C/U separated BNG Architecture

The traditional BNG incorporates user access management functions in addition to router functions. The basic idea of C/U separated BNG is to extract and centralize the user management functions of multiple BNG devices, forming a separate control plane (CP). The router CP and BNG forwarding plane are both preserved on BNG devices in the form of a user plane (UP). As a result, a C/U separated BNG is made up of a CP and a UP.

The C/U separated BNG architecture has the following advantages:

» Decoupling of the forwarding and control planes allows for flexible capacity expansion without restrictions from either plane.
» Centralization and cloudification of the control plane allows for easier centralized management, elastic capacity expansion, and simplified O&M.
» The computing-intensive control plane is suitable for software implementation
» The traffic-intensive forwarding plane is suitable for implementation with dedicated hardware. This also allows for the reuse of existing devices.
» The control and forwarding planes both use standard interfaces. This will promote the standardization and universal application of high-performance forwarding planes.

3.2.1 Logical Architecture

Figure 3-2 shows the logical architecture of a C/U separated BNG.

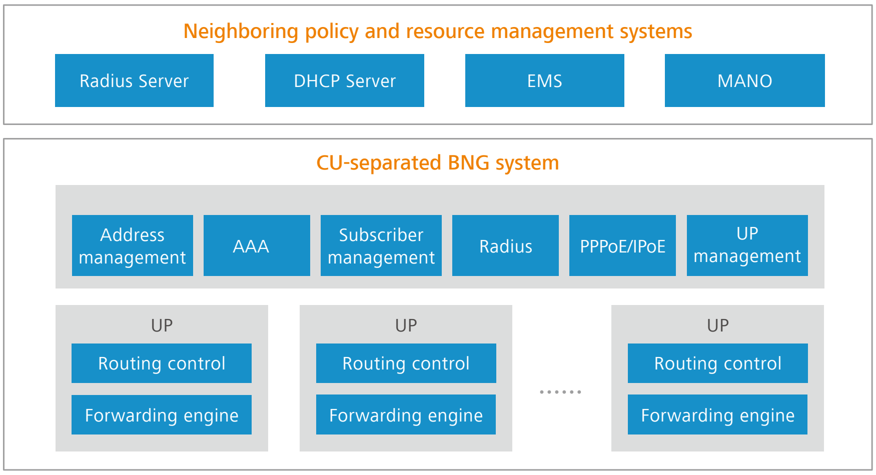


Figure 3-2 Logical architecture of a C/U separated BNG

1. The neighboring policy and resource management systems include:

» Service systems such as the RADIUS server, DHCP server, and EMS
» Infrastructure management system MANO
» Other service systems

2. The CP is a user control management component that supports:

» Unified northbound interfaces (NBIs): For BNG services, external systems will see only one BNG service node.
» Unified southbound interfaces (SBIs): Managed UPs will see only one CP node.
» Unified address pool management
» User management, including user entry management and forwarding policy management (such as access bandwidth and priority management)
» Cooperation with the RADIUS server and other servers to implement AAA for access users
» Cooperation with the DHCP server or use of the local address pool to allocate user addresses
» Processing of user dialup packets such as PPPoE/IPoE packets sent by the UP to complete user access
» Configuration of BNG services through the EMS or command lines and alarm reporting to the EMS
» Management of the UP, UP interface status, and the setup, deletion, maintenance of the access protocol, control, and configuration channels between the UP and CP
» Interaction with MANO systems, complete CP system deployment, and elastic expansion

3. The UP is a network edge and user policy implementation component. It supports:

» Forwarding plane functions on traditional BNG devices, including traffic forwarding, QoS, and traffic statistics collection
» Control plane functions on traditional BNG devices, including routing, multicast, and MPLS
» Configuration of routing services through the EMS or command lines and alarm reporting to the EMS
» CP proxy, which maintains links between the UP and users and reports link failures to the CP

3.2.2 Benefits

1. Increased Resource Utilization

Under the same hardware conditions, the UP supports greater user specifications and the forwarding plane decreases expansion costs with greater efficiency. With the cloudification of BNG control functions, the user specifications of physical devices for the forwarding plane no longer face storage and computing restrictions from the main control board in traditional devices. The specifications of each UP are increased to the total of each board's specifications. Moving the CP to the cloud does not change hardware conditions but increases user specifications by several times.

Sharing of IP addresses leads to greater utilization, simplifying O&M. The IP address pool of a traditional BNG must be planned in advance. Due to differences in the forecasted and actual user conditions, IP address wastage is extremely high. Even though some devices have leftover IP addresses, they are unable to share these IP addresses with other devices. This lack of IP addresses for some devices leads to new users being unable to go online. Moving the CP to the cloud allows for the on-demand allocation of addresses. As a result, IP address utilization increases, O&M is simplified, and OPEX decreases.

2. Simplified O&M for Greater Savings on Network OPEX

Simplified configuration: Basic configurations like AAA, DHCP, and QoS must be performed for each distributed traditional BNG. After the CP and UP are separated, basic device configurations like AAA, DHCP, and QoS only need to be performed on the CP once. The resulting effect will immediately apply to hundreds of UP devices. This eliminates the need for operations on large numbers of UP devices by numerous maintenance personnel.

Simplified service system interconnection: Traditional BNGs and service systems have meshed logical connections. The upgrading and migration of service systems are very complex. After the CP and UP are separated, only the CP needs to interconnect with service systems. Only a single logical connection takes place between the CP and logical service system architecture. The workload of interconnection verification and modification significantly decreases. The entire network will require only a few maintenance personnel for service adjustment and maintenance.

Plug-and-play and automated configuration: The C/U separated BNG system can automatically detect when the UP goes online. The basic, board, and interface configurations of an UP device can be performed on the CP in advance. Field engineers only need to perform required physical operations in the equipment room as instructed. This significantly lowers the skill requirements of field engineers.

Increased user access rate: The improvement in cloud computing capabilities leads to increased speeds in processing control packets and packets triggering user log-in. User experience also improves greatly. Additionally, the system may also avoid the avalanche that occurs due to the pressure imposed by the large number of cloud users.

3. Increased New Service Provisioning Efficiency

Summarizing and categorizing BNG requirements globally, Huawei has discovered that most of them are pertinent to changes in the CP. For example, 60% of requirements include changes in RADIUS attributes and QoS profile sales menus. To carriers with hundreds of devices, an upgrade would require a few months or even one year. Under the C/U separated architecture, only the CP needs to be upgraded, greatly increasing efficiency. More importantly, this increases the provisioning efficiency of new services.

The CP-separated cloud-based BNG architecture borrows centralized control from SDN and device cloudification from NFV. In preserving the high forwarding performance of BNG devices, computing-intensive BNG user management is centralized and cloudified. This not only fulfills the requirements for network functions, performance, maintainability, and rapid provisioning of new services, but also supports the network's evolution towards the cloud-based architecture.

3.3 System Interfaces

Figure 3-3 shows the system interfaces of a C/U separated BNG.

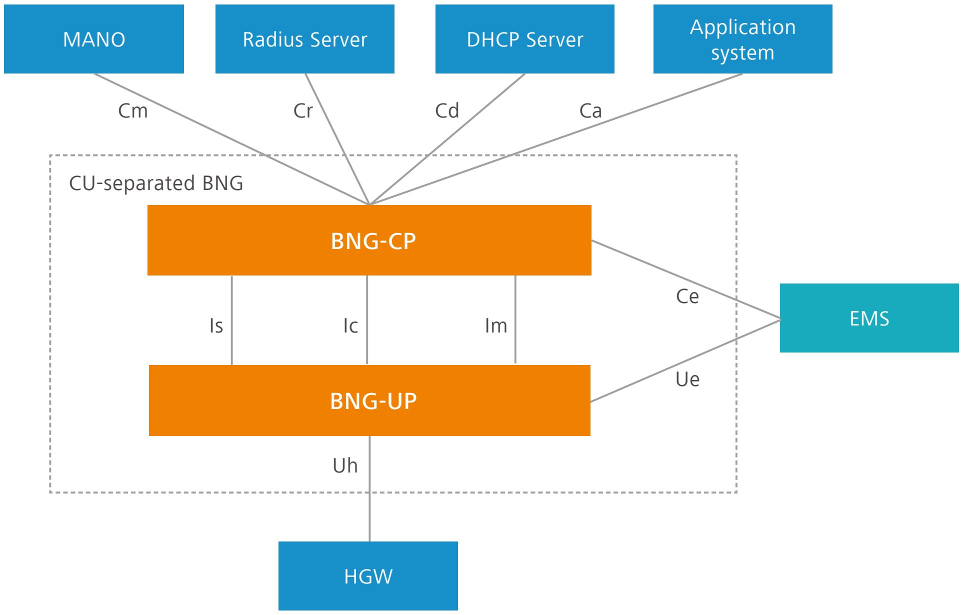


Figure 3-3 System interfaces

1. External interfaces connecting to service systems, application systems, and home gateways:

» Cm interface: interface between the CP and MANO. A CP is a complete VNF whose deployment and lifecycle management are performed through MANO. For interfaces between the CP and MANO, see ETSI standards.

» Cr interface: interface between the CP and RADIUS server. This interface is used for authentication, authorization, and accounting;

» Cd interface: interface between the CP and DHCP server. The remote DHCP server allocates IP addresses through this interface.

» Ca interface: interface between the CP and application system. This interface is used to open up BNG capabilities.

» Network management interface: including Ce interfaces between the CP and EMS and Ue interfaces between the UP and EMS. These interfaces are used to report alarms and deliver service configurations.

» Uh interface: interface between the BNG system and home gateway.

2. Internal interfaces between the CP and UP:

» Service interface Is: The CP and UP use this interface to establish VXLAN tunnels with each other and transmit PPPoE and IPoE packets over the VXLAN tunnels.

» Control interface Ic: The CP uses this interface to deliver service entries, and the UP uses this interface to report service events to the CP. This interface runs OpenFlow.

» Management interface Im: The CP uses this interface to deliver configurations to the UP. This interface runs NETCONF

3.4 Key Technologies

3.4.1 User Online Process

After a BNG service interface on the UP receives PPPoE/IPoE dialup packets, the UP sends the dialup packets to the CP through the service interface. Upon receipt, the CP processes the PPPoE/IPoE state machine and sends a response packet to the UP through the control interface. The UP then responds to the dialup packets through the BNG service interface, bringing the user online.

3.4.2 Elastic CP Scalability

The CP deploys different functions on different VMs in a virtual environment according to the NFV architecture to ensure that the system can elastically scale. The elastic scaling process is in compliance with ETSI standards. The CP completes elastic scaling with the collaboration of MANO.

3.4.3 Hot-Standby/Redundancy

A transition from traditional telecom disaster recovery to IT disaster recovery is made to achieve N:1 hot-standby. After a switchover is performed, attention must be paid to the entry synchronization time and rate. It should be better than the failure time of the traditional BNG.

3.4.4 UP Management by the CP

The CP allows UP devices to dynamically join and leave its management domain and can detect the access status of UP services and process UP user online requests. After a UP device restarts and joins a the management domain of the CP, the CP delivers UP entries to the device. This UP device can then work without being configured.

4 Prospects of Cloud-based Metro Networks

4.1 Cloud-based Metro Network Architecture

Oriented to scenarios such as home broadband and Internet leased lines, Huawei's CloudMetro architecture consists of two parts: a network cloud engine (NCE) deployed on the cloud and an E2E bearer network that supports slicing. The main responsibility of the NCE is to implement network capability orchestration, connection management, user management, security assurance, and O&M. The NCE can be integrated with third-party applications. The basic bearer network supports E2E slicing and can provide differentiated channels based on service requirements, such as delay and bandwidth requirements. The multi-service edge (MSE) can be SRs, BNGs, or other types of devices.

CloudMetro Architecture

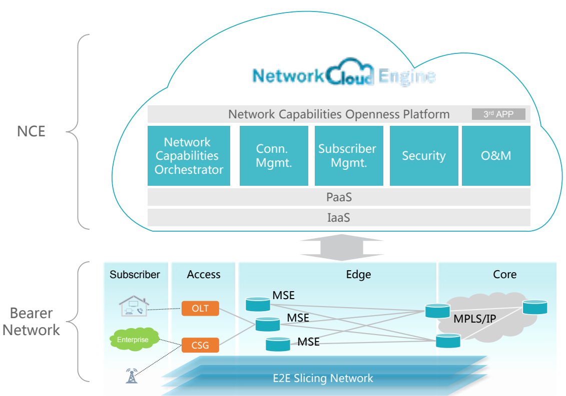


Figure 4-1 CloudMetro architecture

4.2 Cloud-based Metro Network Benefits

Benefit 1: Resource Pooling

The cloud-based architecture decouples the control plane from the forwarding plane, deploys control functions on the cloud, and pools resources, effectively improving resource utilization. With powerful cloud computing capabilities, a single rack can serve tens of millions of users.

Benefit 2: Service Agility, Accelerating New Service Provisioning

The cloud-based architecture provides an on-demand LEGO-style service provisioning capability. By introducing service function chains to allow for on-demand service function selection and deployment, this architecture significantly shortens service TTM, satisfying carriers' differentiated service innovation requirements.

Benefit 3: Operation Automation, Lowering Costs

The forwarding-control separation design allows this architecture to achieve unified service management, centralized resource control, and flexible resource scheduling across layers, domains, and vendors. This architecture supports online self-service service subscription, one-touch service provisioning, cloud-based service upgrades, and visualized O&M, effectively reducing OPEX.

Benefit 4: Open Platform, Win-Win Outcome

The standard northbound interfaces open to third parties allow more applications to be supported and online remote integration verification. Moving from independent development to joint development with partners, Huawei aims to cooperate with industry partners to achieve win-win outcomes.

5 References

General Technical Requirements for China Mobile's C/U separated BNG System

CloudMetro: Unified Metro Network for Cloud Evolution

6 Acronyms and Abbreviations

Acronym or Abbreviation	Full Name
NCE	Network Cloud Engine
MSE	Multi-Service Edge
PaaS	platform as a service
IaaS	infrastructure as a service
BRAS	broadband remote access server
BNG	broadband network gateway
TIC	Telecom Integrated Cloud
SDN	software-defined networking
NFV	network functions virtualization
MANO	management and orchestration
CP	control plane
UP	user plane
VXLAN	Virtual Extensible LAN

Remark: In this document, BNG represents the BRAS function

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