Abstract

With the rapid development of mobile services, especially in the Long Term Evolution (LTE) era, radio access networks (RANs) become IP-oriented. Being primary NEs on RANs, microwave equipment also needs to join the ALL IP and IP-to-edge trend. To address the issue, Huawei is the first vendor in the industry who provides one box-based L3VPN technology and hierarchical virtual private network (HVPN) microwave solution. This document describes L3VPN principles, HVPN solution, key technologies, and typical HVPN applications.

Keywords

IP RAN, LTE, L3VPN, HVPN, Multiprotocol Label Switching (MPLS), Border Gateway Protocol (BGP)
## Contents

**About This Document** ........................................................................................................ ii

1 **Background** ................................................................................................................. 4  
1.1 Evolution of RANs ........................................................................................................... 4  
1.2 Demands and Challenges for IP RANs ........................................................................... 5  
1.3 HVPN Technological Characteristics ............................................................................ 5

2 **HVPN Solution** .............................................................................................................. 7  
2.1 Overview .......................................................................................................................... 7  
2.2 IGP on a Public Network .................................................................................................. 8  
2.3 RSVP-TE Tunnels ............................................................................................................. 8  
2.4 Unified NMS .................................................................................................................... 9  
2.5 IP FPM ............................................................................................................................ 11  
2.6 OAM ............................................................................................................................... 11

3 **Successful Story** ............................................................................................................. 13  
3.1 The First L3 Microwave Hop in Country M ..................................................................... 13  
3.2 Success in Global ............................................................................................................. 13
1 Background

1.1 Evolution of RANs

RANs in LTE era must be able to carry S1 and X2 services.

- S1 interface

As LTE networks support S-GW pools and MME pools, S1 interfaces must support multihoming.

Being the interface between eNodeBs and serving gateways (S-GWs) or mobility management entities (MMEs), S1 interfaces are classified into S1-U interfaces and S1-C interfaces based on the services carried.

S1-U interfaces carry user-plane data and connect eNodeBs to S-GWs, S1-C interfaces carry control-plane data and connect eNodeBs to MMEs.

- X2 interface
To ensure user data exchanged between eNodeBs when a user roams between the eNodeBs, X2 interfaces are introduced to LTE networks. Being the interface between neighboring eNodeBs, X2 interfaces require RANs provide forwarding channels between neighboring eNodeBs. To meet this requirement, logical connections must be set up between neighboring eNodeBs.

1.2 Demands and Challenges for IP RANs

With IP-orientation of base stations and wireless data service development, operators always face the following challenges during the MBB reconstruction:

- **Bearing various services on same network**
  LTE service backhaul: X2 interfaces on LTE eNodeBs require that the partial mesh logical connection function should be supported not only at the access layer but also at the edge of the aggregation layer of a backhaul network.

- **Scalability**
  Operators’ networks have layered architectures, the core layer, aggregation layer, and access layer. From the core layer to the access layer, the required performance of the devices is declined while the network size is increased. Generally, traditional operators’ MPLS VPNs cover the aggregation layer (metropolitan area network [MAN]) only or core layer, consisting of several hundreds of IP devices. IP RANs cover the core layer, aggregation layer, and access layer. A large number of cell site gateways (CSGs) (up to 10,000 IP devices) are deployed at the access layer.

1.3 HVPN Technological Characteristics

To meet the specific requirements of IP RANs, IP RANs are expected to provide multi-service bearing capability, high scalability, high reliability, easy maintenance and deployment. To achieve cost efficient device model based on existing physical topologies of operators’ networks, the HVPN solution is designed.
• Multi-service backhaul
  An HVPN provides hybrid backhaul ability for 2G emulated services, 3G services, and LTE services. With a flexible route reflector (RR) policy configured on the aggregation site gateway (ASG)/superstratum provider edge (SPE), shortest-path LTE X2 interface interconnections are supported. This enables powerful multi-service backhaul capability and a simple architecture to the HVPN, and also makes the network easy to construct, decrease the HVPN device costs.

• High scalability
  Different from the single-plane architecture of an MPLS VPN, an HVPN has a layered architecture, mapping the physical layered network topology. That is, with the HVPN technologies, an MPLS VPN is divided into several small networks, improving the network scalability, decreasing the requirements for CSG performance, and meeting the cost efficient device model required from operators.

• Fast E2E protection switching capability
  Technologies such as Interior Gateway Protocol (IGP) loop-free alternate (LFA), traffic engineering (TE) hot-standby, and VPN fast reroute (FRR) ensure switching within 50 ms upon a link fault and switching within 200 ms upon a node fault.
2 HVPN Solution

2.1 Overview

Figure 2-1 RTN+CX HVPN solution

An HVPN uses a hierarchical architecture including access layer, aggregation layer, and core layer. On an HVPN, CSGs are access NEs on the base station side, ASGs are aggregation NEs of CSGs, and radio network controller site gateways (RSGs) connect to base station controllers. An HVPN has the following characteristics:

- Although the HVPN solution looks complicated, it is easy to configure. In addition, when NMS supports HVPN configurations, an HVPN can be configured similarly in E2E mode. Therefore, personnel skill requirements for operating and maintaining HVPNs are not high.

- The HVPN solution completely isolates an access or aggregation ring from all the other access or aggregation rings at the protocol layer. To be specific, when a link or node on a ring is faulty, route convergence is implemented only within the ring, and NEs outside the ring do not sense the fault. In addition, when the homing relationship needs to be adjusted for a base station or a node needs to be added to a ring, only configurations of NEs on the access ring need to be adjusted, and configurations of the aggregation ring do not need to be adjusted.
2.2 IGP on a Public Network

It is recommended that a routing protocol running on a public network uses a hierarchical model, which has the following benefits:

- NEs on rings do not need to support high class protocol specifications, enabling the deployment of large-scale networks.
- Protocol databases being synchronized within a ring effectively reduces the CPU calculation workload and the convergence time.
- A fault on a ring affects only services carried on the ring and do not affect services carried on other rings, enhancing the robustness of the network.

Figure 2-2 uses the Intermediate System to Intermediate System (IS-IS) protocol as an example to illustrate the hierarchical deployment model of an IGP on a public network.

![Hierarchical deployment model of IS-IS](image)

2.3 RSVP-TE Tunnels

![Hierarchical deployment model of RSVP-TE tunnels](image)
For the HVPN solution, RSVP-TE is recommended for TE tunnel establishment and has the following advantages:

- Tunnel establishment can be highly controlled and is not based on forwarding equivalence classes (FECs).
- High network security: authentication can be based on peers and interfaces.
- RSVP-TE provides various protection switching methods. TE hot-standby is recommended.

**Figure 2-4** Basic principles of the HVPN solution

**2.4 Unified NMS**

- CSGs are plug-and-play.

CSGs support plug-and-play feature only if the NMS provides DCN automatic deployment. That is, the DCN automatic deployment protocol discovers new online CSGs automatically and the Link Layer Discovery Protocol (LLDP) protocol discovers the topological relationships of the new online CSGs.
Service trails are visualized.

To adapt dynamic changes in service trails on an IP RAN, the unified NMS provides visualized service trail management. That is, E2E trail information can be obtained based on the source and sink information. E2E visualization of various service and network trails such as LSPs, PWs, and VPNs helps operators to monitor and diagnose faults in services and networks.

**Figure 2-5 Unified NMS for an HVPN**

**Figure 2-6 Trail visualization**
2.5 IP FPM

IP flow performance monitoring (FPM) measures the performance of multipoint-to-multipoint (MP2MP) service flows, for example, packet loss and service trail delay.

IP FPM has the following features:

- High precision, the performance of service flows is measured in E2E mode
- Supporting measurement at multiple points and wide variety of scenarios: IP FPM achieves measurement and synchronization for multi-trail and multi-direction service flows, supports multihoming access and complex networking models, such as L2+L3 E2E, load sharing, and link aggregation.

Figure 2-7 E2E performance monitoring and troubleshooting

2.6 OAM

The HVPN solution provides a wide variety of OAM methods, which help locate faults at each layer of a RAN quickly.

- Functions
  - Link layer: IEEE 802.3ah
  - Network layer: BFD and MPLS OAM (RFC4379 and RFC5085)
  - Service layer: Internet Control Message Protocol (ICMP) ping, smart ping, and three-segment ping (available on the NMS)
- Fault locating
Inter-network demarcation:
- Ping the IP address of a NodeB on an RNC to check the connectivity from the RNC to the NodeB.
- Ping the IP address of an RSG on an RNC to check the connectivity from the RNC to the RSG.
- Ping the IP address of a CSG on an RNC to check the connectivity from the RNC to the CSG.

Intra-network demarcation:
- Perform an IP ping/trace test to locate a faulty point at the control layer.
- Perform an LSP ping/trace test to locate a faulty point at the tunnel layer.
- Perform an IP ping/trace test on the Versatile Routing Platform (VRP) to locate a faulty point at the service layer.
3 Successful Story

3.1 The First L3 Microwave Hop in Country M

April 2014, the first L3 Microwave hop was built between site NOC and Operator T office at country M.

![Image](figure3-1.png)

Figure 3-1 Roof of operator office, the first call was successfully reached with L3 Microwave

3.2 Success in Global

More and more operators are choosing L3 Microwave HVPN solution now.

More than 3,500 hops of L3 Microwave are providing service to people in Southeast Asia, Africa and Latin America. This number is growing fast.