# 5 Creating an IPv6 Network

## 5.1 Introduction

### 5.1.1 About This Lab

Internet Protocol Version 6 (IPv6) is also called IP Next Generation (IPng). Designed by the Internet Engineering Task Force (IETF), IPv6 is an upgraded version of IPv4.

IPv6 have the following advantages over IPv4:

- Infinite address space
- Hierarchical address structure
- Plug-and-play
- Simplified packet header
- Security
- Mobility
- Enhanced QoS features

This chapter describes how to set up an IPv6 network to help you understand the basic principles and address configuration of IPv6.

### 5.1.2 Objectives

Upon completion of this task, you will be able to:

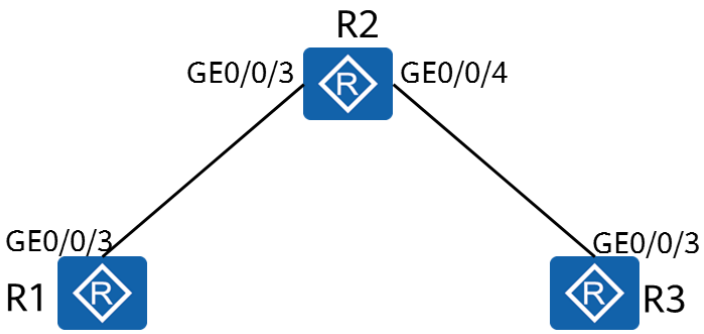
- Learn how to configure static IPv6 addresses
- Learn how to configure a DHCPv6 server
- Learn how to configure stateless addresses
- Learn how to configure static IPv6 routes
- Learn how to view IPv6 information

### 5.1.3 Networking Topology

An enterprise needs to deploy IPv6 on its network.

1. Configure static IPv6 addresses for the two interfaces of R2.
2. Configure stateless address autoconfiguration on GigabitEthernet0/0/3 of R1.
3. Configure an IPv6 address for GigabitEthernet0/0/3 of R3 using DHCPv6.

**Figure 5-1** Lab topology for creating an IPv6 network




# 5.2 Lab Configuration

## 5.2.1 Configuration Roadmap

1. Configure static IPv6 addresses.
2. Configure DHCPv6.
3. Configure IPv6 stateless address allocation.
4. Display IPv6 addresses.

## 5.2.2 Configuration Procedure

**Step 1** Complete basic device configuration.

# Name the devices.

The details are not provided here.

**Step 2** Configure IPv6 functions on the devices and interfaces.

# Enable IPv6 globally.

```
[R1]ipv6
```

The **ipv6** command enables the device to forward IPv6 unicast packets, including sending and receiving local IPv6 packets.

```
[R2]ipv6
```

```
[R3]ipv6
```

# Enable IPv6 on the interface.

```
[R1]interface GigabitEthernet 0/0/3
```

The **ipv6 enable** command enables the IPv6 function on an interface.

```
[R1-GigabitEthernet0/0/3]ipv6 enable
[R1-GigabitEthernet0/0/3]quit
```

```
[R2]interface GigabitEthernet 0/0/3
[R2-GigabitEthernet0/0/3]ipv6 enable
[R2-GigabitEthernet0/0/3]quit
[R2]interface GigabitEthernet 0/0/4
[R2-GigabitEthernet0/0/4]ipv6 enable
[R2-GigabitEthernet0/0/4]quit
```

```
[R3]interface GigabitEthernet 0/0/3
[R3-GigabitEthernet0/0/3]ipv6 enable
[R3-GigabitEthernet0/0/3]quit
```

**Step 3** Configure a link-local address for the interface and test the configuration.

# Configure an interface to automatically generate a link-local address.

```
[R1]interface GigabitEthernet 0/0/3
```

The **ipv6 address auto link-local** command enables the generation of a link-local address for an interface.

Only one link-local address can be configured for each interface. To prevent link-local address conflict, automatically generated link-local addresses are recommended. After an IPv6 global unicast address is configured for an interface, a link-local address will be automatically generated.

```
[R1-GigabitEthernet0/0/3]ipv6 address auto link-local
[R1-GigabitEthernet0/0/3]quit
```

```
[R2]interface GigabitEthernet 0/0/3
[R2-GigabitEthernet0/0/3]ipv6 address auto link-local
[R2-GigabitEthernet0/0/3]quit
[R2]interface GigabitEthernet 0/0/4
[R2-GigabitEthernet0/0/4]ipv6 address auto link-local
[R2-GigabitEthernet0/0/4]quit
```

```
[R3]interface GigabitEthernet 0/0/3
[R3-GigabitEthernet0/0/3]ipv6 address auto link-local
[R3-GigabitEthernet0/0/3]quit
```

# Display the IPv6 status of the interface and test the connectivity.

```
<R1>display ipv6 interface GigabitEthernet 0/0/3
GigabitEthernet0/0/3 current state : UP
IPv6 protocol current state : UP                    //The physical and protocol status is Up.
IPv6 is enabled, link-local address is FE80::2E0:FCFF:FE4D:355    //The link-local address for the interface has been
generated.
  No global unicast address configured
  Joined group address(es):
    FF02::1:FF4D:355
    FF02::2
    FF02::1
  MTU is 1500 bytes
  ND DAD is enabled, number of DAD attempts: 1
  ND reachable time is 30000 milliseconds
  ND retransmit interval is 1000 milliseconds
  Hosts use stateless autoconfig for addresses
```

```
<R2>display ipv6 interface GigabitEthernet 0/0/3
GigabitEthernet0/0/3 current state : UP
IPv6 protocol current state : UP
IPv6 is enabled, link-local address is FE80::2E0:FCFF:FE12:6486
  No global unicast address configured
```

```
  Joined group address(es):
    FF02::1:FF12:6486
    FF02::2
    FF02::1
  MTU is 1500 bytes
  ND DAD is enabled, number of DAD attempts: 1
  ND reachable time is 30000 milliseconds
  ND retransmit interval is 1000 milliseconds
  Hosts use stateless autoconfig for addresses

<R2>display ipv6 interface GigabitEthernet 0/0/4
GigabitEthernet0/0/4 current state : UP
IPv6 protocol current state : UP
IPv6 is enabled, link-local address is FE80::2E0:FCFF:FE12:6487
  No global unicast address configured
  Joined group address(es):
    FF02::1:FF12:6487
    FF02::2
    FF02::1
  MTU is 1500 bytes
  ND DAD is enabled, number of DAD attempts: 1
  ND reachable time is 30000 milliseconds
  ND retransmit interval is 1000 milliseconds
  Hosts use stateless autoconfig for addresses
```

```
<R3>display ipv6 interface GigabitEthernet 0/0/3
GigabitEthernet0/0/4 current state : UP
IPv6 protocol current state : UP
IPv6 is enabled, link-local address is FE80::2E0:FCFF:FE3C:5133
  No global unicast address configured
  Joined group address(es):
    FF02::1:FF3C:5133
    FF02::2
    FF02::1
  MTU is 1500 bytes
  ND DAD is enabled, number of DAD attempts: 1
  ND reachable time is 30000 milliseconds
  ND retransmit interval is 1000 milliseconds
  Hosts use stateless autoconfig for addresses
```

# Test network connectivity between R1 and R2.

```
<R1>ping ipv6 FE80::2E0:FCFF:FE12:6486 -i GigabitEthernet 0/0/3
  PING FE80::2E0:FCFF:FE12:6486 : 56  data bytes, press CTRL_C to break
    Reply from FE80::2E0:FCFF:FE12:6486
    bytes=56 Sequence=1 hop limit=64  time = 90 ms
    Reply from FE80::2E0:FCFF:FE12:6486
    bytes=56 Sequence=2 hop limit=64  time = 10 ms
    Reply from FE80::2E0:FCFF:FE12:6486
    bytes=56 Sequence=3 hop limit=64  time = 20 ms
    Reply from FE80::2E0:FCFF:FE12:6486
    bytes=56 Sequence=4 hop limit=64  time = 10 ms
    Reply from FE80::2E0:FCFF:FE12:6486
    bytes=56 Sequence=5 hop limit=64  time = 30 ms

  --- FE80::2E0:FCFF:FE12:6486 ping statistics ---
    5 packet(s) transmitted
    5 packet(s) received
    0.00% packet loss
round-trip min/avg/max = 10/32/90 ms
```

When you ping a link-local address, you must specify the source interface or source IPv6 address.

**Step 4** Configure static IPv6 addresses on R2.

```
[R2]interface GigabitEthernet 0/0/3
[R2-GigabitEthernet0/0/3]ipv6 address 2000:0012::2 64
[R2-GigabitEthernet0/0/3]quit
[R2]interface GigabitEthernet 0/0/4
```

```
[R2-GigabitEthernet0/0/4]ipv6 address 2000:0023::2 64
[R2-GigabitEthernet0/0/4]quit
```

**Step 5** Configure the DHCPv6 server function on R2 and configure R3 to obtain IPv6 addresses through DHCPv6.

# Configure the DHCPv6 server function.

```
[R2]dhcp enable
[R2]dhcpv6 pool pool1
An IPv6 address pool named pool1 is created.
[R2-dhcpv6-pool-pool1]address prefix 2000:0023::/64
The IPv6 address prefix is configured.
[R2-dhcpv6-pool-pool1]dns-server 2000:0023::2
The IP address of the DNS server is specified.
[R2-dhcpv6-pool-pool1]quit
[R2]interface GigabitEthernet 0/0/4
[R2-GigabitEthernet0/0/4]dhcpv6 server pool1
[R2-GigabitEthernet0/0/4]quit
```

# Configure the DHCPv6 client function.

```
[R3]dhcp enable
Info: The operation may take a few seconds. Please wait for a moment.done.
[R3]interface GigabitEthernet 0/0/3
[R3-GigabitEthernet0/0/3]ipv6 address auto dhcp
[R3-GigabitEthernet0/0/3]quit
```

# Display the client address and DNS server information.

```
[R3]display ipv6 interface brief
*down: administratively down
(l): loopback
(s): spoofing
Interface                  Physical              Protocol
GigabitEthernet0/0/3       up                    up
[IPv6 Address] 2000:23::1

[R3]display dns server
Type:
D:Dynamic     S:Static
No configured ip dns servers.
No.  Type  IPv6 Address                          Interface Name
1    D     2000:23::2                           -
```

*GigabitEthernet0/0/3 on R3 has obtained an IPv6 global unicast address.*
*How is the DHCPv6 server configured to allocate gateway information to clients?*

The DHCPv6 server does not allocate an IPv6 gateway address to a client.

When the DHCPv6 stateful mode is configured, DHCPv6 clients learn the default route of the IPv6 gateway using the **ipv6 address auto global default** command. When the DHCPv6 stateless mode is configured, DHCPv6 clients learn the global unicast IPv6 address and the default route to the IPv6 gateway through this command. Ensure that the interface of the peer device connected to the local device has been enabled to send RA packets using the **undo ipv6 nd ra halt** command.

# Configure DHCPv6 server to allocate the gateway address to clients.

```
[R2]interface GigabitEthernet 0/0/4
[R2-GigabitEthernet0/0/4]undo ipv6 nd ra halt
```

The **undo ipv6 nd ra halt** command enables a system to send RA packets. By default, router interfaces do not send RA packets.

```
[R2-GigabitEthernet0/0/4]ipv6 nd autoconfig managed-address-flag
```

The **ipv6 nd autoconfig managed-address-flag** command sets the "managed address configuration" flag (M flag) in RA messages, indicating whether hosts should use stateful autoconfiguration to obtain addresses. By default, the flag is not set.

- If the M flag is set, a host obtains an IPv6 address through stateful autoconfiguration.
- If the M flag is not set, a host uses stateless autoconfiguration to obtain an IPv6 address, that is, the host generates an IPv6 address based on the prefix information in the RA packet.

```
[R2-GigabitEthernet0/0/4]ipv6 nd autoconfig other-flag
```

The **ipv6 nd autoconfig other-flag** command sets the "Other Configuration" flag (O flag) in RA messages. By default, the flag is not set.

- If the O flag is set, a host uses stateful autoconfiguration to obtain other configuration parameters (excluding IPv6 address), including the router lifetime, neighbor reachable time, retransmission interval, and PMTU.
- If this flag is cleared, a host can obtain configurations (excluding IPv6 address), such as the router lifetime, neighbor reachable time, retransmission interval, and PMTU in stateless autoconfiguration. This means that a routing device advertises these configurations using RA messages to the attached hosts.

```
[R2-GigabitEthernet0/0/4]quit
```

# Configure the client to learn the default route through RA messages.

```
[R3]interface GigabitEthernet 0/0/3
[R3-GigabitEthernet0/0/3] ipv6 address auto global default
```

# Display the routes of R3.

```
[R3]display ipv6 routing-table
Routing Table : Public
      Destinations : 4        Routes : 4

Destination  : ::                                PrefixLength : 0
NextHop      : FE80::A2F4:79FF:FE5A:CDAE         Preference   : 64
Cost         : 0                                 Protocol     : Unr
RelayNextHop : ::                                TunnelID     : 0x0
Interface    : GigabitEthernet0/0/3              Flags        : D

Destination  : ::1                               PrefixLength : 128
NextHop      : ::1                               Preference   : 0
Cost         : 0                 Protocol        : Direct
RelayNextHop : ::                TunnelID        : 0x0
Interface    : InLoopBack0       Flags           : D

Destination  : 2000:23::1                        PrefixLength : 128
NextHop      : ::1                               Preference   : 0
Cost         : 0                 Protocol        : Direct
RelayNextHop : ::                TunnelID        : 0x0
Interface    : GigabitEthernet0/0/3              Flags        : D

Destination  : FE80::                            PrefixLength : 10
NextHop      : ::                Preference      : 0
Cost         : 0                 Protocol        : Direct
RelayNextHop : ::                TunnelID        : 0x0
Interface    : NULL0             Flags           : D
```

**Step 6** Configure R1 to obtain an IPv6 address in stateless mode.

# Enable RA on GigabitEthernet0/0/3 of R2.

```
[R2]interface GigabitEthernet 0/0/3
[R2-GigabitEthernet0/0/3]undo ipv6 nd ra halt
```

```
# Enable stateless address autoconfiguration on GigabitEthernet0/0/3 of R1.
[R1]interface GigabitEthernet 0/0/3
[R1-GigabitEthernet0/0/3] ipv6 address auto global
```

# Display the IP address configuration of R1.

```
[R1]display ipv6 interface brief
*down: administratively down
(l): loopback
(s): spoofing
Interface                  Physical            Protocol
GigabitEthernet0/0/3       up                  up
[IPv6 Address] 2000:12::2E0:FCFF:FE4D:355
```

*GigabitEthernet0/0/3 of R1 generates an IPv6 global unicast address based on the IPv6 address prefix obtained from the RA message sent by R2 and the locally generated interface ID.*

**Step 7** Configure an IPv6 static route.

# Configure a static route on R1 to enable connectivity between GigabitEthernet0/0/3 on R1 and GigabitEthernet0/0/3 on R3.

```
[R1]ipv6 route-static 2000:23:: 64 2000:12::2
Info: The destination address and mask of the configured static route mismatched, and the static route 2000:23::/64 was generated.
```

# Test connectivity.

```
[R1]ping ipv6 2000:23::1
  PING 2000:23::1 : 56  data bytes, press CTRL_C to break
    Reply from 2000:23::1
    bytes=56 Sequence=1 hop limit=63  time = 20 ms
    Reply from 2000:23::1
    bytes=56 Sequence=2 hop limit=63  time = 20 ms
    Reply from 2000:23::1
    bytes=56 Sequence=3 hop limit=63  time = 30 ms
    Reply from 2000:23::1
    bytes=56 Sequence=4 hop limit=63  time = 20 ms
    Reply from 2000:23::1
    bytes=56 Sequence=5 hop limit=63  time = 30 ms

  --- 2000:23::1 ping statistics ---
    5 packet(s) transmitted
    5 packet(s) received
    0.00% packet loss
round-trip min/avg/max = 20/24/30 ms
```

R1 has a static route to the network 2000:23::/64. R3 obtains the default route through DHCPv6. Therefore, GigabitEthernet0/0/3 on R1 and GigabitEthernet0/0/3 on R3 can communicate with each other.

# Display the IPv6 neighbor information.

```
[R1]display ipv6 neighbors
------------------------------------------------------------------------------
IPv6 Address      : 2000:12::2
Link-layer        : 00e0-fc12-6486                State       : STALE
Interface         : GE0/0/3                       Age         : 8
VLAN              : -                             CEVLAN              : -
VPN name     :                          Is Router   : TRUE
Secure FLAG       : UN-SECURE

IPv6 Address      : FE80::2E0:FCFF:FE12:6486
Link-layer        : 00e0-fc12-6486                State       : STALE
Interface         : GE0/0/3                       Age         : 8
VLAN              : -                             CEVLAN              : -
VPN name          :                          Is Router   : TRUE
Secure FLAG       : UN-SECURE
------------------------------------------------------------------------------
Total: 2      Dynamic: 2      Static: 0
```

**----End**

# 5.3 Verification

The details are not provided here.

# 5.4 Configuration Reference

Configuration on R1

```
#
 sysname R1
#
ipv6
#
interface GigabitEthernet0/0/3
 ipv6 enable
 ipv6 address auto link-local
 ipv6 address auto global
#
ipv6 route-static 2000:23:: 64 2000:12::2
#
return
```

Configuration on R2

```
#
 sysname R2
#
ipv6
#
dhcp enable
#
dhcpv6 pool pool1
 address prefix 2000:23::/64
 dns-server 2000:23::2
#
interface GigabitEthernet0/0/3
 ipv6 enable
 ipv6 address 2000:12::2/64
 ipv6 address auto link-local
 undo ipv6 nd ra halt
interface GigabitEthernet0/0/4
#
ipv6 enable
 ipv6 address 2000:23::2/64
 ipv6 address auto link-local
 undo ipv6 nd ra halt
 ipv6 nd autoconfig managed-address-flag
 dhcpv6 server pool1
#
return
```

Configuration on R3

```
#
 sysname R3
#
ipv6
#
dhcp enable
#
interface GigabitEthernet0/0/3
 ipv6 enable
 ipv6 address auto link-local
```

```
 ipv6 address auto global default
 ipv6 address auto dhcp
#
return
```

# 5.5 Quiz

1. Why the source interface must be specified in Step 3 (testing the connectivity between link-local addresses) but not in Step 7 (testing the connectivity between GUA addresses)?
2. Describe the difference between stateful address configuration and stateless address configuration and explain why.