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Executive Summary
This document provides an overview of Dynamic Host Configuration Protocol (DHCP) and how Spirent TestCenter can be used to validate some common DHCPv4 options and capabilities.

The target audience of this document is system test, integration test and product development engineers who need to use Spirent TestCenter.

Overview of DHCPv4
The Dynamic Host Configuration Protocol (DHCP) is used to pass configuration information and assign IP address to hosts on a TCPIP network. DHCP is based on the Bootstrap Protocol (BOOTP), adding the capability of automatic allocation of reusable network addresses and additional configuration options. DHCP captures the behavior of BOOTP relay agents and DHCP participants can interoperate with BOOTP participants. A DHCP relay agent is an Internet host or router that passes DHCP messages between DHCP clients and DHCP servers.

The above diagram displays a basic DHCP process:
- DHCP client sends a DHCPDISCOVER broadcast message to locate a DHCP server.
- A DHCP server on the local subnet offers configuration parameters, including an IP address to the client in a DHCPOFFER unicast message.
- The DHCP client returns a formal request for the offered IP address to the server in DHCPREQUEST broadcast message.
- The DHCP server confirms that the IP address has actually been located for use by the client by returning the final DHCPACK unicast message.
Here is a typical DHCP use scene:

![DHCP Diagram](image)

*Figure 2. Typical DHCP use scene*

The relevant RFCs are listed as below:

- RFC 2131 Dynamic Host Configuration Protocol
- RFC 1533 DHCP Options and BOOTP Vendor Extensions
- RFC 3046 DHCP Relay Agent Information Option
- RFC 6607 Virtual Subnet Selection Options for DHCPv4 and DHCPv6

**Using Spirent TestCenter with DHCPv4**

Spirent TestCenter provides the following capabilities to test and validate DHCP protocol functionality and user scenarios:

- DHCP message and state machine. Spirent TestCenter can simulate DHCP client, DHCP relay agent and DHCP server, which sends and receives DHCP messages. On receiving DHCP messages, Spirent TestCenter DHCP device switches state according to DHCP standard.
- DHCP options. DHCP behavior can be extended by DHCP options. Spirent TestCenter supports pre-defined DHCP options and custom options, by which user can configure most DHCP option on Spirent TestCenter DHCP device.
- DHCP address assignment. Spirent TestCenter DHCP server provides multiple strategies on assigning IP addresses.
- DHCP scalability test. DHCP server usually provides DHCP service to multiple DHCP clients. The performance of DHCP server needs to be measured to ensure its service quality. Spirent TestCenter supports up to 107520 DHCP clients for each port. Spirent TestCenter also support up to 1000 sessions per second DHCP setup rate.
Test case—DHCP option 82 sub-options support

Overview

The Dynamic Host Configuration Protocol (DHCP) basically assumes a single routing domain between the DHCP client and DHCP server. In some network designs, the DHCP server cannot directly communicate with DHCP clients. Customers may choose this design to make critical infrastructure servers inaccessible and to protect the DHCP server from client attacks.

Relay agents are used to forward requests and replies between clients and servers when they are not on the same physical subnet. In all cases, the DHCP relay agent must be able to communicate directly with both the DHCP server and DHCP client. By using the relay agent information option (option 82), the DHCP relay agent can include additional information about itself when forwarding client-originated DHCP packets to a DHCP server.

DHCP relay agent uses a few sub-options to extend its behavior. Currently, Spirent TestCenter pre-defined DHCP option 82 sub-options are shown as below:

- **Agent Circuit ID (sub-option 1).** This sub-option may be added by DHCP relay agents which terminate switched or permanent circuits. It encodes an agent-local identifier of the circuit from which a DHCP client-to-server packet was received. It is intended for use by agents in relaying DHCP responses back to the proper circuit. DHCP server might use the circuit ID for IP and other parameter assignment.

- **Agent Remote ID (sub-option 2).** This sub-option may be added by DHCP relay agents which terminate switched or permanent circuits and have mechanisms to identify the remote host end of the circuit. DHCP server may use this option for IP and other parameter assignment.

- **Link Selection (sub-option 5).** This sub-option is used by any DHCP relay agent that desires to specify a subnet/link for a DHCP client request that it is relaying but needs the subnet/link specification to be different from the IP address the DHCP server should use when communicating with the relay agent. The link selection sub-option provides a mechanism to separate the subnet/link on which the DHCP client resides from the gateway address (giaddr), which can be used to communicate with the relay agent by the DHCP server. The relay agent will set the sub-option to the correct subscriber subnet and the DHCP server will use that value to assign an IP address rather than the giaddr value. The relay agent will set the giaddr to its own IP address so that DHCP messages are routable over the network.

- **Server Identifier Override (sub-option 11).** This sub-option allows DHCP relay agent to specify a new value for the server ID option, which is inserted by the DHCP server in reply packet. This sub-option allows DHCP relay agent to act as the actual DHCP server such that the renew requests will come to the relay agent rather than the DHCP server directly. The server ID override sub-option contains the incoming interface IP address, which is the IP address on the relay agent that is accessible from the client. The DHCP client uses this information to send all renew and release request packets to the relay agent. The relay agent adds all of the appropriate sub-options and then forwards renew and release request packets to the original DHCP server.

- **DHCPv4 Virtual Subnet Selection (sub-option 151).** This sub-option determines the VPN on which a DHCP client is supposed to receive an IP address. DHCP server might assign address based on this option. For clients on different VPN, they may share the same IP address.
**Objective**

For this test case, the DUT can be either relay agent or DHCP server. So the test objective varies:

- DUT works as relay agent. In this case, DUT is expected to add sub-option 151 for DHCP clients from different virtual subnet and forward these requests to Spirent TestCenter DHCP server. Spirent TestCenter DHCP server assigns address of different network to DHCP clients from different virtual subnet.

- DUT works as DHCP server. In this case, Spirent TestCenter port simulates relay agent and send DHCP message with pre-configured sub-option 151. DUT as DHCP server is expected to process sub-option 151 based on its local policy and assign address back to relay agent.

**Test Setup**

The topology of this test case is pretty simple: a DHCP relay agent directly connects to a DHCP server. The DHCP relay agent and DHCP server are all simulated by Spirent TestCenter devices. DHCP server tries to provide DHCP service for DHCP clients from different virtual subnet.

![Test Setup Diagram](image-url)
Configuring the test

Steps to configure DHCP relay agent:

1. On the first port, launch “Create Device” wizard by click “Add” button on device configuration panel. After “Select Ports”, choose “Access” in “Protocol Technologies”, enable “DHCPv4 Relay Agent” and finish the wizard.

2. Change “Device Count” to 2, now we have 2 DHCP subscribers.

3. Configure DHCPv4 Virtual Subnet Selection option for relay agent. Check “Enable Relay Agent VPN ID”, set “Relay Agent VPN ID” to “spirent@s”. To do this, Spirent TestCenter would add a Virtual Subnet Selection sub-option in DHCP message. And the Virtual Subnet Selection option value for the two DHCP subscribers are “spirent0” and “spirent1”.

Figure 4. Create DHCP relay agent

Figure 5. Change Device Count

Figure 6. Configure DHCPv4 Virtual Subnet Selection
Steps to configure DHCP server:

1. On the second port, add a device and enable DHCP server.

2. Set “Address Assign Strategy” to “Relay Agent VPN ID”. Setting this, DHCP server would assign address based on DHCPv4 Virtual Subnet Selection sub-option.

3. Add two relay agent address pools.

4. Configure Relay Agent VPN ID for each pool. Set the first pool to “spirent0” and the second pool to “spirent1”. It means that for DHCP relay agent whose Virtual Subnet Selection sub-option value is “spirent0”, DHCP server would assign address from the first pool, for those whose value is “spirent1”, DHCP server would assign address from the second pool.
Executing the test

1. Bring ports online and click "Apply".

![Figure 11. Apply configuration](image)

2. Start DHCP server.

![Figure 12. Start DHCP server](image)


![Figure 13. Bind DHCP relay agent](image)
Analyzing the results

After DHCP relay agent reaching “Bound” state, check session results. There are two DHCP sessions go to “Bound” state and the IP is got from different relay agent pool:

Figure 14.DHCP Detailed Session Information
Test case—DHCP overlapping address pools

Overview

DHCP relay support for Multiprotocol Label Switching (MPLS) VPNs enables a network administrator to conserve address space by allowing overlapping addresses. The relay agent can support multiple clients on different VPNs, and many of these clients from different VPNs can share the same IP address.

In some environments, a relay agent resides in a network element that also has access to one or more MPLS VPNs. A DHCP server that provides service to DHCP clients on those different VPNs must locate the VPN in which each client resides. The network element that contains the relay agent typically captures the VPN association of the DHCP client and includes this information in the relay agent information option of the DHCP packet.

In this use case, Spirent TestCenter DHCP server provides overlapping address pool support for DUT relay agent.

Objective

In this case, DUT usually work as DHCP relay agent. DUT is expected to add sub-option 1 for DHCP requests from different circuit. Spirent TestCenter DHCP server is expected to process sub-option 1 and reuse its address space for clients from different circuit.

Test Setup

The topology of this test case is pretty simple: a DHCP relay agent directly connects to a DHCP server. The DHCP relay agent and DHCP server are all simulated by Spirent TestCenter devices. DHCP server tried to provide DHCP service for DHCP clients from different circuit.
Configuring the test

Steps to configure DHCP relay agent:

1. On the first port, launch “Create Device” wizard by click “Add” button on device configuration panel. After “Select Ports”, choose “Access” in “Protocol Technologies”, enable “DHCPv4 Relay Agent” and finish the wizard.

![Figure 16.Create DHCP relay agent](image)

2. Change “Device Count” to 2, now we have 2 DHCP subscribers.

![Figure 17.Change Device Count](image)

3. Configure DHCPv4 Agent Circuit ID option for relay agent. Check “Enable Relay Agent Circuit ID”, set “Relay Agent Circuit ID” to “spirent@s”. To do this, Spirent TestCenter would add an Agent Circuit ID sub-option in DHCP message. And the Agent Circuit ID option value for the two DHCP subscribers are “spirent0” and “spirent1”.

![Figure 18.Configure Agent Circuit ID](image)
Steps to configure DHCP server:

1. On the second port, add a device and enable DHCP server.

   ![Figure 19. Enable DHCP server](image1)

2. Set “Address Assign Strategy” to “Relay Agent Circuit ID”. Setting this, DHCP server would assign address based on Relay Agent Circuit ID sub-option.

   ![Figure 20. Configure Address Assign Strategy](image2)

3. Enable Overlapping Addresses function.

   ![Figure 21. Enable Overlapping Addresses](image3)

4. Add a relay agent address pool and configure “Relay Agent Circuit ID” property. Set “Relay Agent Circuit ID” to “spirent@s” and set “Maximum Relay Agent Circuit ID Count”. By doing this, DHCP server would share address space for circuit ID “spirent0” and “spirent1”.

   ![Figure 22. Add relay agent address pool](image4)
Executing the test

1. Bring ports online and click “Apply”
2. Start DHCP server
3. Bind DHCP relay agent

Analyzing the results

After DHCP relay agent reaching “Bound” state, check session results. There are two DHCP sessions go to “Bound” state and the IP is the same “1.1.1.1”:

![Figure 23.Session results](image-url)
Acronyms

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<td>Bootstrap Protocol</td>
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<tr>
<td>DHCP</td>
<td>Dynamic Host Configuration Protocol</td>
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<td>DUT</td>
<td>Device under Testing</td>
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<tr>
<td>MPLS</td>
<td>Multiprotocol Label Switching</td>
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<tr>
<td>TCP/IP</td>
<td>Transmission Control Protocol/Internet Protocol</td>
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