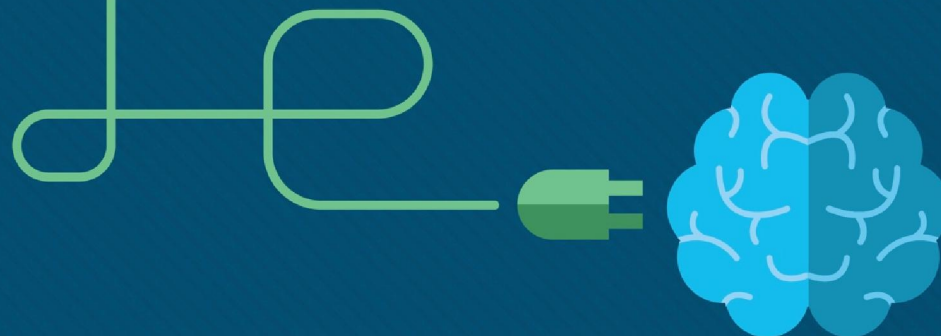




Module 7: DHCPv4

Switching, Routing and Wireless
Essentials v7.0 (SRWE)

ENOCH, Joseph Diema (Instructor)



Module Objectives

Module Title: DHCPv4

Module Objective: Implement DHCPv4 to operate across multiple LANs

Topic Title	Topic Objective
DHCP4 Concepts	Explain how DHCPv4 operates in a small- to medium-sized business network.
Configure a Cisco IOS DHCP4 Server	Configure a router as a DHCPv4 server.
Configure a DHCP4 Client	Configure a router as a DHCPv4 client.

7.1 DHCPv4 Concepts

DHCPv4 Concepts

DHCPv4 Server and Client

- Dynamic Host Configuration Protocol v4 (DHCPv4) assigns IPv4 addresses and other network configuration information dynamically. Because desktop clients typically make up the bulk of network nodes, DHCPv4 is an extremely useful and timesaving tool for network administrators.
- A dedicated DHCPv4 server is scalable and relatively easy to manage. However, in a small branch or SOHO location, a Cisco router can be configured to provide DHCPv4 services without the need for a dedicated server. Cisco IOS software supports an optional, full-featured DHCPv4 server.
- The DHCPv4 server dynamically assigns, or leases, an IPv4 address from a pool of addresses for a limited period of time chosen by the server, or until the client no longer needs the address.
- Clients lease the information from the server for an administratively defined period. Administrators configure DHCPv4 servers to set the leases to time out at different intervals. The lease is typically anywhere from 24 hours to a week or more. When the lease expires, the client must ask for another address, although the client is typically reassigned the same address.

DHCPv4 Concepts

DHCPv4 Operation

DHCPv4 works in a client/server mode. When a client communicates with a DHCPv4 server, the server assigns or leases an IPv4 address to that client.

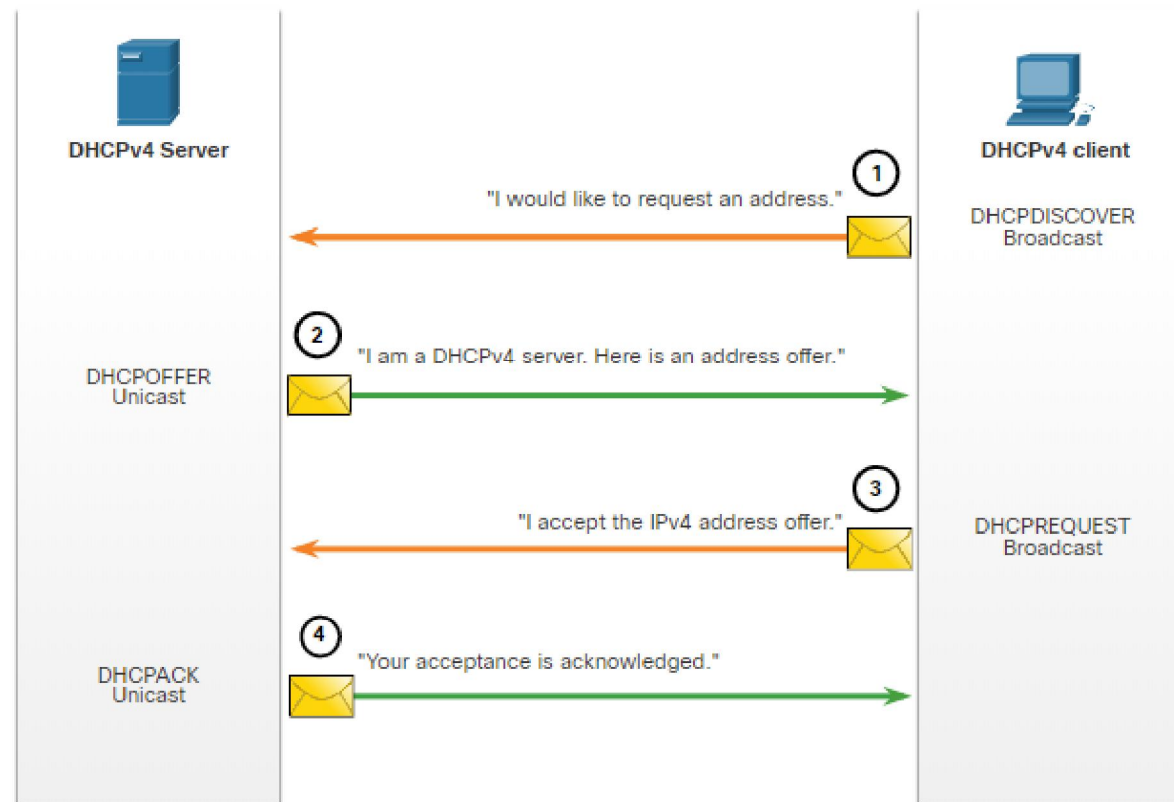
- The client connects to the network with that leased IPv4 address until the lease expires. The client must contact the DHCP server periodically to extend the lease.
- This lease mechanism ensures that clients that move or power off do not keep addresses that they no longer need.
- When a lease expires, the DHCP server returns the address to the pool where it can be reallocated as necessary.

DHCPv4 Concepts

Steps to Obtain a Lease

When the client boots (or otherwise wants to join a network), it begins a four-step process to obtain a lease:

1. DHCP Discover (DHCPDISCOVER)
2. DHCP Offer (DHCPOFFER)
3. DHCP Request (DHCPREQUEST)
4. DHCP Acknowledgment (DHCPACK)



DHCPv4 Concepts

Steps to Renew a Lease

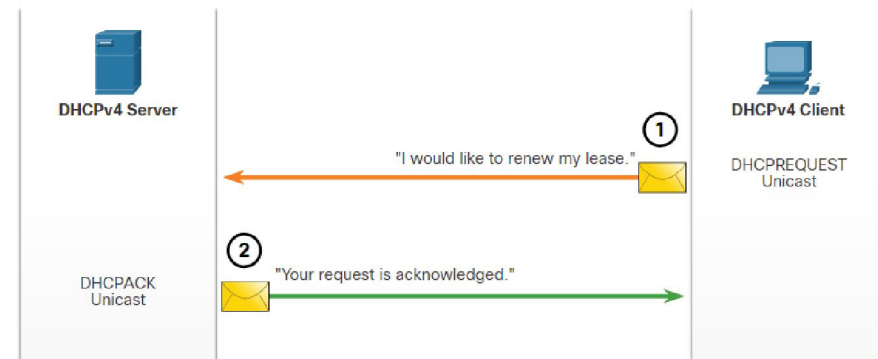
Prior to lease expiration, the client begins a two-step process to renew the lease with the DHCPv4 server, as shown in the figure:

1. DHCP Request (DHCPREQUEST)

Before the lease expires, the client sends a DHCPREQUEST message directly to the DHCPv4 server that originally offered the IPv4 address. If a DHCPACK is not received within a specified amount of time, the client broadcasts another DHCPREQUEST so that one of the other DHCPv4 servers can extend the lease.

2. DHCP Acknowledgment (DHCPACK)

On receiving the DHCPREQUEST message, the server verifies the lease information by returning a DHCPACK.



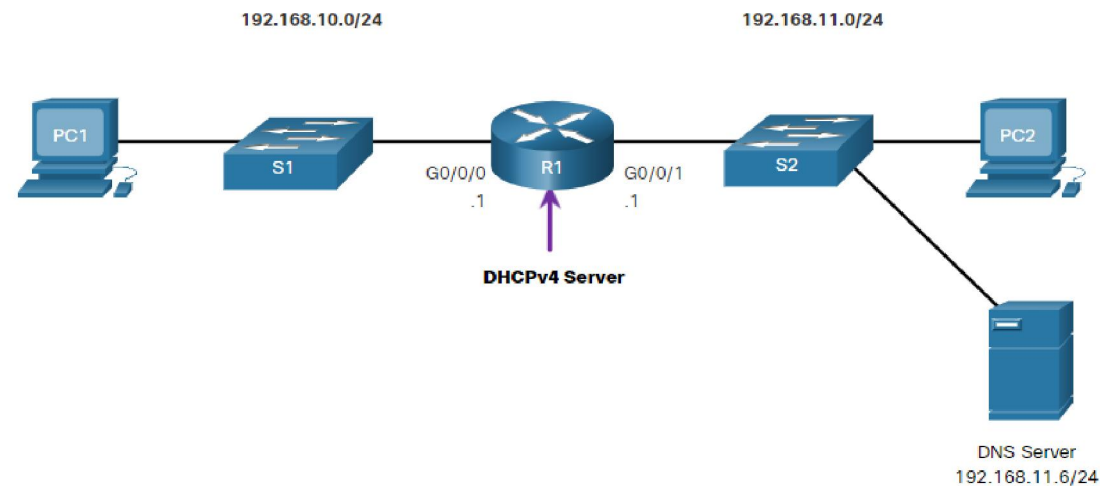
Note: These messages (primarily the DHCPOFFER and DHCPACK) can be sent as unicast or broadcast according to IETF RFC 2131.

7.2 Configure a Cisco IOS DHCPv4 Server

Configure a Cisco IOS DHCPv4 Server

Cisco IOS DHCPv4 Server

Now you have a basic understanding of how DHCPv4 works and how it can make your job a bit easier. A Cisco router running Cisco IOS software can be configured to act as a DHCPv4 server. The Cisco IOS DHCPv4 server assigns and manages IPv4 addresses from specified address pools within the router to DHCPv4 clients.



Configure a Cisco IOS DHCPv4 Server

Steps to Configure a Cisco IOS DHCPv4 Server

Use the following steps to configure a Cisco IOS DHCPv4 server:

- **Step 1.** Exclude IPv4 addresses. A single address or a range of addresses can be excluded by specifying the *low-address* and *high-address* of the range. Excluded addresses should be those addresses that are assigned to routers, servers, printers, and other devices that have been, or will be, manually configured. You can also enter the command multiple times. The command is **ip dhcp excluded-address *low-address* [*high-address*]**
- **Step 2.** Define a DHCPv4 pool name. The **ip dhcp pool *pool-name*** command creates a pool with the specified name and puts the router in DHCPv4 configuration mode, which is identified by the prompt **Router(dhcp-config)#**.

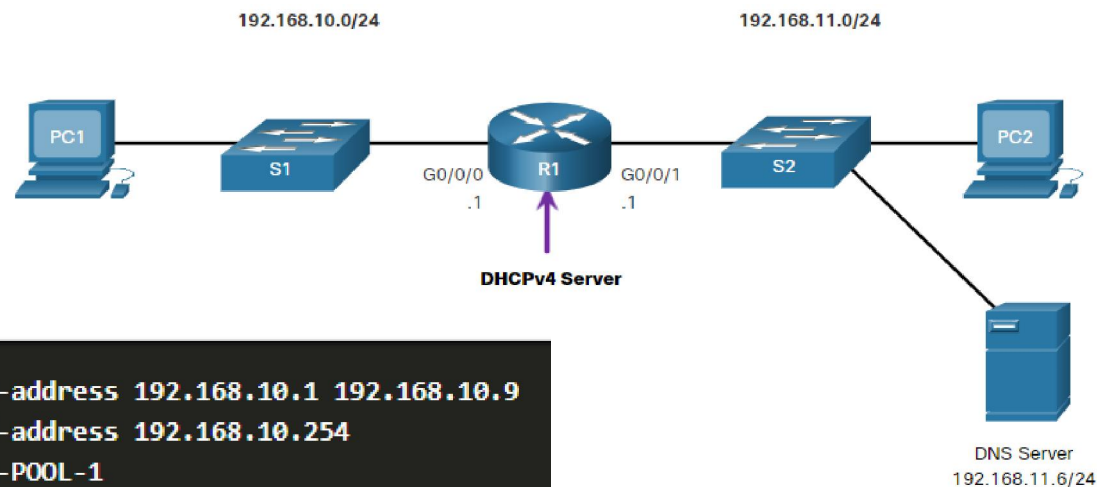
Configure a Cisco IOS DHCPv4 Server

Steps to Configure a Cisco IOS DHCPv4 Server (Cont.)

- **Step 3.** Configure the DHCPv4 pool. The address pool and default gateway router must be configured. Use the **network** statement to define the range of available addresses. Use the **default-router** command to define the default gateway router. These commands and other optional commands are shown in the table.

Task	IOS Command
Define the address pool.	network <i>network-number</i> [<i>mask</i> / <i>prefix-length</i>]
Define the default router or gateway.	default-router <i>address</i> [<i>address2</i> <i>address8</i>]
Define a DNS server.	dns-server <i>address</i> [<i>address2</i> ... <i>address8</i>]
Define the domain name.	domain-name <i>domain</i>
Define the duration of the DHCP lease.	lease { <i>days</i> [<i>hours</i> [<i>minutes</i>]] infinite }
Define the NetBIOS WINS server.	netbios-name-server <i>address</i> [<i>address2</i> ... <i>address8</i>]

Configure a Cisco IOS DHCPv4 Server Configuration Example



```
R1(config)# ip dhcp excluded-address 192.168.10.1 192.168.10.9
R1(config)# ip dhcp excluded-address 192.168.10.254
R1(config)# ip dhcp pool LAN-POOL-1
R1(dhcp-config)# network 192.168.10.0 255.255.255.0
R1(dhcp-config)# default-router 192.168.10.1
R1(dhcp-config)# dns-server 192.168.11.5
R1(dhcp-config)# domain-name example.com
R1(dhcp-config)# end
R1#
```

Configure a Cisco IOS DHCPv4 Server

DHCPv4 Verification

Use the commands in the table to verify that the Cisco IOS DHCPv4 server is operational.

Command	Description
show running-config section dhcp	Displays the DHCPv4 commands configured on the router.
show ip dhcp binding	Displays a list of all IPv4 address to MAC address bindings provided by the DHCPv4 service.
show ip dhcp server statistics	Displays count information regarding the number of DHCPv4 messages that have been sent and received

Configure a Cisco IOS DHCPv4 Server

Verify DHCPv4 is Operational

Verify the DHCPv4 Configuration: As shown in the example, the **show running-config | section dhcp** command output displays the DHCPv4 commands configured on R1. The **| section** parameter displays only the commands associated with DHCPv4 configuration.

```
R1# show running-config | section dhcp
ip dhcp excluded-address 192.168.10.1 192.168.10.9
ip dhcp excluded-address 192.168.10.254
ip dhcp pool LAN-POOL-1
  network 192.168.10.0 255.255.255.0
  default-router 192.168.10.1
  dns-server 192.168.11.5
  domain-name example.com
```

Configure a Cisco IOS DHCPv4 Server

Verify DHCPv4 is Operational (Cont.)

Verify DHCPv4 Bindings: As shown in the example, the operation of DHCPv4 can be verified using the **show ip dhcp binding** command. This command displays a list of all IPv4 address to MAC address bindings that have been provided by the DHCPv4 service.

```
R1# show ip dhcp binding
Bindings from all pools not associated with VRF:
IP address      Client-ID/      Lease expiration    Type      State      Interface
                Hardware address/
                User name
192.168.10.10    0100.5056.b3ed.d8  Sep 15 2019 8:42 AM Automatic Active
GigabitEthernet0/0/0
```

Configure a Cisco IOS DHCPv4 Server

Verify DHCPv4 is Operational (Cont.)

Verify DHCPv4 Statistics: The output of the **show ip dhcp server statistics** is used to verify that messages are being received or sent by the router. This command displays count information regarding the number of DHCPv4 messages that have been sent and received.

```
R1# show ip dhcp server statistics
Memory usage           19465
Address pools          1
Database agents        0
Automatic bindings     2
Manual bindings        0
Expired bindings       0
Malformed messages     0
Secure arp entries     0
Renew messages         0
Workspace timeouts     0
Static routes          0
Relay bindings         0
Relay bindings active   0
Relay bindings terminated 0
Relay bindings selecting 0
Message                Received
BOOTREQUEST            0
DHCPDISCOVER           4
DHCPREQUEST            2
DHCPDECLINE            0
DHCPRELEASE            0
DHCPIFORM              0
```


Configure a Cisco IOS DHCPv4 Server

Verify DHCPv4 is Operational (Cont.)

Verify DHCPv4 Client Received IPv4

Addressing: The **ipconfig**

/all command, when issued on PC1, displays the TCP/IP parameters, as shown in the example. Because PC1 was connected to the network segment 192.168.10.0/24, it automatically received a DNS suffix, IPv4 address, subnet mask, default gateway, and DNS server address from that pool. No DHCP-specific router interface configuration is required. If a PC is connected to a network segment that has a DHCPv4 pool available, the PC can obtain an IPv4 address from the appropriate pool automatically.

```
C:\Users\Student> ipconfig /all
Windows IP Configuration

Host Name . . . . . : ciscolab
Primary Dns Suffix . . . . . :
Node Type . . . . . : Hybrid
IP Routing Enabled. . . . . : No
WINS Proxy Enabled. . . . . : No

Ethernet adapter Ethernet0:

    Connection-specific DNS Suffix  . : example.com
    Description . . . . . : Realtek PCIe GBE Family Controller
    Physical Address. . . . . : 00-05-9A-3C-7A-00
    DHCP Enabled. . . . . : Yes
    Autoconfiguration Enabled . . . . : Yes
    IPv4 Address. . . . . : 192.168.10.10
    Subnet Mask . . . . . : 255.255.255.0
    Lease Obtained . . . . . : Saturday, September 14, 2019 8:42:22AM
    Lease Expires . . . . . : Sunday, September 15, 2019 8:42:22AM
    Default Gateway . . . . . : 192.168.10.1
    DHCP Server . . . . . : 192.168.10.1
    DNS Servers . . . . . : 192.168.11.5
```

Configure a Cisco IOS DHCPv4 Server

Disable the Cisco IOS DHCPv4 Server

The DHCPv4 service is enabled by default. To disable the service, use the **no service dhcp** global configuration mode command. Use the **service dhcp** global configuration mode command to re-enable the DHCPv4 server process, as shown in the example. Enabling the service has no effect if the parameters are not configured.

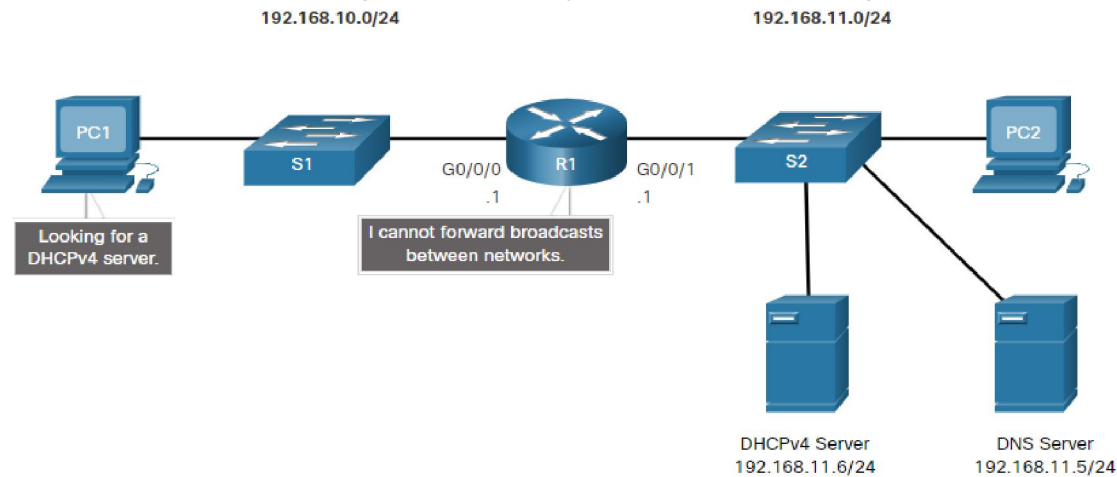
Note: Clearing the DHCP bindings or stopping and restarting the DHCP service may result in duplicate IP addresses being temporarily assigned on the network.

```
R1(config)# no service dhcp
R1(config)# service dhcp
R1(config)#
```

Configure a Cisco IOS DHCPv4 Server

DHCPv4 Relay

- In a complex hierarchical network, enterprise servers are usually located centrally. These servers may provide DHCP, DNS, TFTP, and FTP services for the network. Network clients are not typically on the same subnet as those servers. In order to locate the servers and receive services, clients often use broadcast messages.
- In the figure, PC1 is attempting to acquire an IPv4 address from a DHCPv4 server using a broadcast message. In this scenario, R1 is not configured as a DHCPv4 server and does not forward the broadcast. Because the DHCPv4 server is located on a different network, PC1 cannot receive an IP address using DHCP. R1 must be configured to relay DHCPv4 messages to the DHCPv4 server.



Configure a Cisco IOS DHCPv4 Server DHCPv4 Relay (Cont.)

- Configure R1 with the **ip helper-address address** interface configuration command. This will cause R1 to relay DHCPv4 broadcasts to the DHCPv4 server. As shown in the example, the interface on R1 receiving the broadcast from PC1 is configured to relay DHCPv4 address to the DHCPv4 server at 192.168.11.6.
- When R1 has been configured as a DHCPv4 relay agent, it accepts broadcast requests for the DHCPv4 service and then forwards those requests as a unicast to the IPv4 address 192.168.11.6. The network administrator can use the **show ip interface** command to verify the configuration.

```
R1(config)# interface g0/0/0
R1(config-if)# ip helper-address 192.168.11.6
R1(config-if)# end
R1#
```

```
R1# show ip interface g0/0/0
GigabitEthernet0/0/0 is up, line protocol is up
Internet address is 192.168.10.1/24
Broadcast address is 255.255.255.255
Address determined by setup command
MTU is 1500 bytes
Helper address is 192.168.11.6
(output omitted)
```

Configure a Cisco IOS DHCPv4 Server

Other Service Broadcasts Relayed

DHCPv4 is not the only service that the router can be configured to relay. By default, the **ip helper-address** command forwards the following eight UDP services:

- Port 37: Time
- Port 49: TACACS
- Port 53: DNS
- Port 67: DHCP/BOOTP server
- Port 68: DHCP/BOOTP client
- Port 69: TFTP
- Port 137: NetBIOS name service
- Port 138: NetBIOS datagram service

Configure a Cisco IOS DHCPv4 Server

Packet Tracer – Configure DHCPv4

In this Packet Tracer Activity, you will complete the following objectives:

- Part 1: Configure a Router as a DHCP Server
- Part 2: Configure DHCP Relay
- Part 3: Configure a Router as a DHCP Client
- Part 4: Verify DHCP and Connectivity

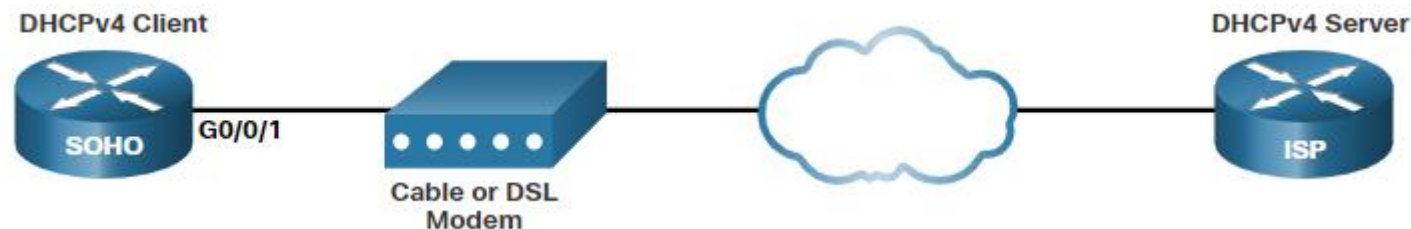
7.3 Configure a DHCPv4 Client

Configure a DHCPv4 Client

Cisco Router as a DHCPv4 Client

There are scenarios where you might have access to a DHCP server through your ISP. In these instances, you can configure a Cisco IOS router as a DHCPv4 client.

- Sometimes, Cisco routers in a small office or home office (SOHO) and branch sites have to be configured as DHCPv4 clients in a similar manner to client computers. The method used depends on the ISP. However, in its simplest configuration, the Ethernet interface is used to connect to a cable or DSL modem.
- To configure an Ethernet interface as a DHCP client, use the **ip address dhcp interface** configuration mode command.
- In the figure, assume that an ISP has been configured to provide select customers with IP addresses from the 209.165.201.0/27 network range after the G0/0/1 interface is configured with the **ip address dhcp** command.



Configure a DHCPv4 Client Configuration Example

- To configure an Ethernet interface as a DHCP client, use the **ip address dhcp** interface configuration mode command, as shown in the example. This configuration assumes that the ISP has been configured to provide select customers with IPv4 addressing information.
- The **show ip interface g0/1** command confirms that the interface is up and that the address was allocated by a DHCPv4 server.

```
SOHO(config)# interface G0/0/1
SOHO(config-if)# ip address dhcp
SOHO(config-if)# no shutdown
Sep 12 10:01:25.773: %DHCP-6-ADDRESS_ASSIGN: Interface GigabitEthernet0/0/1 assigned DHCP address
209.165.201.12, mask 255.255.255.224, hostname SOHO
```

```
SOHO# show ip interface g0/0/1
GigabitEthernet0/0/1 is up, line protocol is up
  Internet address is 209.165.201.12/27
  Broadcast address is 255.255.255.255
  Address determined by DHCP
(output omitted)
```

Configure a DHCPv4 Client Home Router as a DHCPv4 Client

Home routers are typically already set to receive IPv4 addressing information automatically from the ISP. This is so that customers can easily set up the router and connect to the internet.

- For example, the figure shows the default WAN setup page for a Packet Tracer wireless router. Notice that the internet connection type is set to **Automatic Configuration - DHCP**. This selection is used when the router is connected to a DSL or cable modem and acts as a DHCPv4 client, requesting an IPv4 address from the ISP.
- Various manufacturers of home routers will have a similar setup.

The screenshot displays the configuration interface for a 'Wireless Tri-Band Home Router' (Firmware Version: v0.9.7). The top navigation bar includes 'Setup', 'Wireless', 'Security', 'Access Restrictions', 'Applications & Gaming', 'Administration', and 'Status'. The 'Setup' section is further divided into 'Basic Setup', 'CDNS', 'MAC Address Clone', and 'Advanced Routing'. The 'Internet Setup' section is active, showing the 'Internet Connection type' set to 'Automatic Configuration - DHCP'. Below this, 'Optional Settings (required by some internet service providers)' are visible, including fields for 'Host Name', 'Domain Name', 'MTU' (set to 1500), and 'Size' (set to 1500). A 'Help...' button is located on the right side of the configuration area.

7.4 Module Practice and Quiz

Packet Tracer – Implement DHCPv4

In this Packet Tracer, you will complete the following objectives:

- Part 1: Configure a Router as a DHCP Server
- Part 2: Configure DHCP Relay
- Part 3: configure a Router as a DHCP Client

Lab – Implement DHCPv4

In this lab, you will complete the following objectives:

- Part 1: Build the Network and Configure Basic Device Settings
- Part 2: Configure and Verify Two DHCPv4 Servers on R1
- Part 3: Configure and Verify a DHCP Relay on R2

What Did I Learn In This Module?

- The DHCPv4 server dynamically assigns, or leases, an IPv4 address to a client from a pool of addresses for a limited period of time chosen by the server, or until the client no longer needs the address.
- The DHCPv4 lease process begins with the client sending message requesting the services of a DHCP server. If there is a DHCPv4 server that receives the message it will respond with an IPv4 address and possible other network configuration information.
- The client must contact the DHCP server periodically to extend the lease. This lease mechanism ensures that clients that move or power off do not keep addresses that they no longer need.
- When the client boots (or otherwise wants to join a network), it begins a four-step process to obtain a lease: DHCPDISCOVER, then DHCPOFFER, then DHCPREQUEST, and finally DHCPACK. Prior to lease expiration, the client begins a two-step process to renew the lease with the DHCPv4 server: DHCPREQUEST then DHCPACK.
- A Cisco router running Cisco IOS software can be configured to act as a DHCPv4 server.
- Use the following steps to configure a Cisco IOS DHCPv4 server: exclude IPv4 addresses, define a DHCPv4 pool name, and configure the DHCPv4 pool.
- Verify your configuration using the **show running-config | section dhcp**, **show ip dhcp binding**, and **show ip dhcp server statistics** commands.
- The DHCPv4 service is enabled, by default. To disable the service, use the **no service dhcp** global configuration mode command.

What Did I Learn In This Module? (Cont.)

- Network clients are not typically on the same subnet as enterprise servers providing DHCP, DNS, TFTP, and FTP services for the network. In order to locate the servers and receive services, clients often use broadcast messages. The router must be configured to relay DHCPv4 messages to the DHCPv4 server.
- The network administrator can configure the router with the **ip helper-address address** interface configuration command and use the **show ip interface** command to verify the configuration.
- By default, the ip helper-address command forwards the following eight UDP services:
 - Port 37: Time
 - Port 49: TACACS
 - Port 53: DNS
 - Port 67: DHCP/BOOTP server
 - Port 68: DHCP/BOOTP client
 - Port 69: TFTP
 - Port 137: NetBIOS name service
 - Port 138: NetBIOS datagram service
- To configure an Ethernet interface as a DHCP client, use the **ip address dhcp** interface configuration mode command.
- Home routers are typically already set to receive IPv4 addressing information automatically from the ISP. The internet connection type is set to Automatic Configuration - DHCP. This selection is used when the router is connected to a DSL or cable modem and acts as a DHCPv4 client, requesting an IPv4 address from the ISP.

New Terms and Commands

- Dynamic Host Configuration Protocol (DHCP)
- DHCP Discover (DHCPDISCOVER)
- DHCP Offer (DHCPOFFER)
- DHCP Request (DHCPREQUEST)
- DHCP Acknowledgment (DHCPACK)
- **ip dhcp excluded-address low-address [high-address]**
- **ip dhcp pool name**
- **network network-number [mask | /prefix-length]**
- **default-router address [address2 ... address8]**
- **dns-server address [address2 ... address8]**
- **domain-name domain**
- **lease {days [hours [minutes]] | infinite}**
- **netbios-name-server address [address2 ... address8]**
- **show running-config | section dhcp**
- **show ip dhcp binding**
- **show ip dhcp server statistics**
- **[no] service dhcp**
- **ip helper-address address**
- **ip address dhcp**

