TRƯỜNG ĐẠI HỌC CÔNG NGHỆ THÔNG TIN – ĐHQG-HCM
Khoa Mạng máy tính & Truyền thông

DHCP & NAT

NT132 – Quản trị mạng và hệ thống

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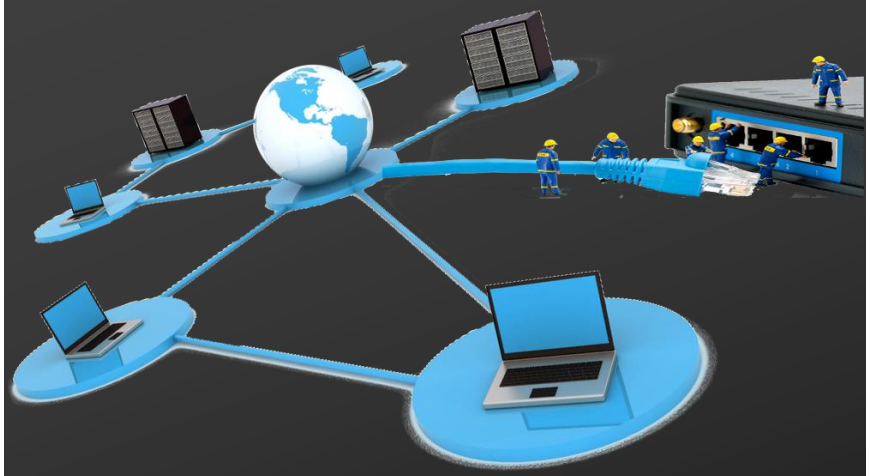


Nội dung

DHCP & NAT

Hôm nay học gì?

1. DHCP
2. NAT

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.

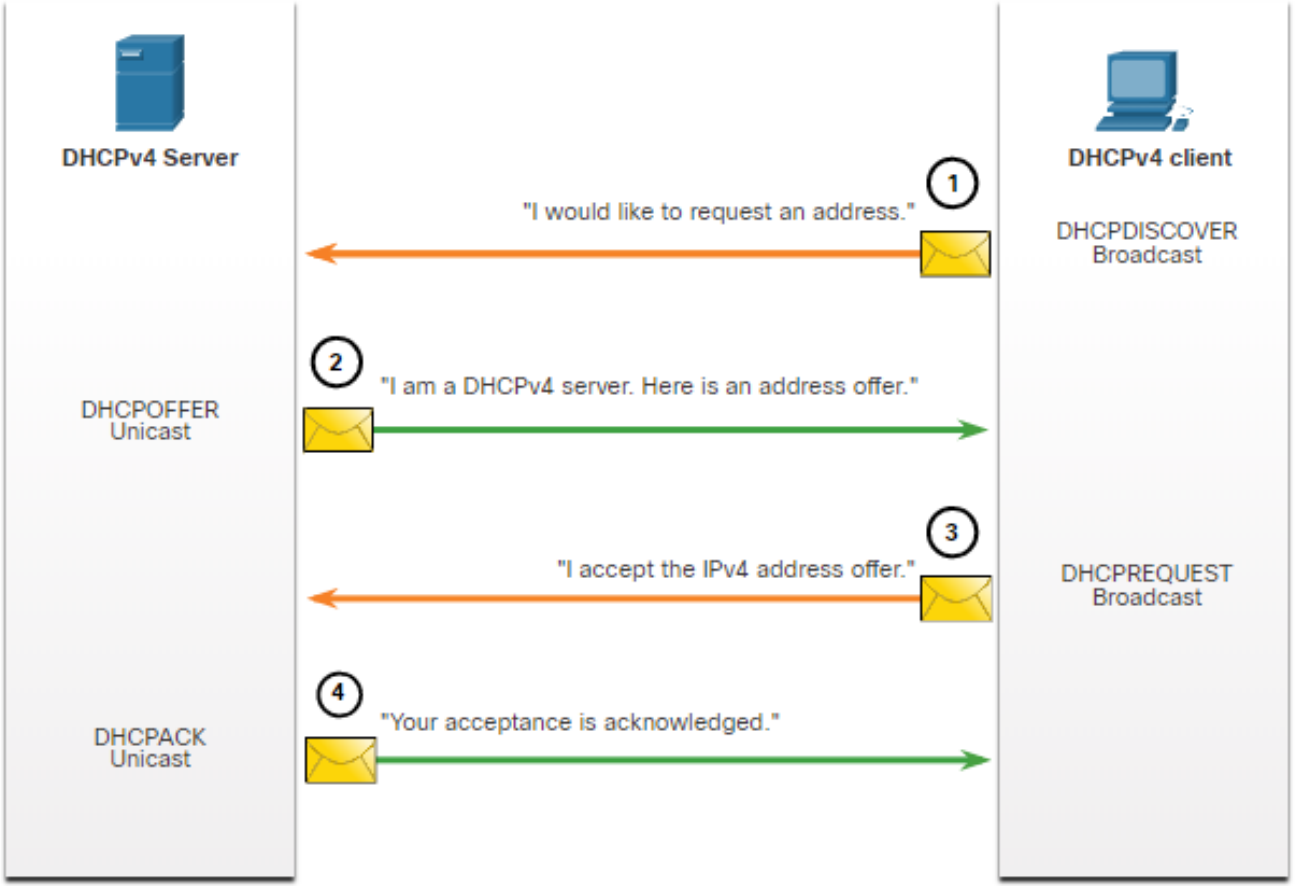
DHCPv4 Operation

- 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.

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)

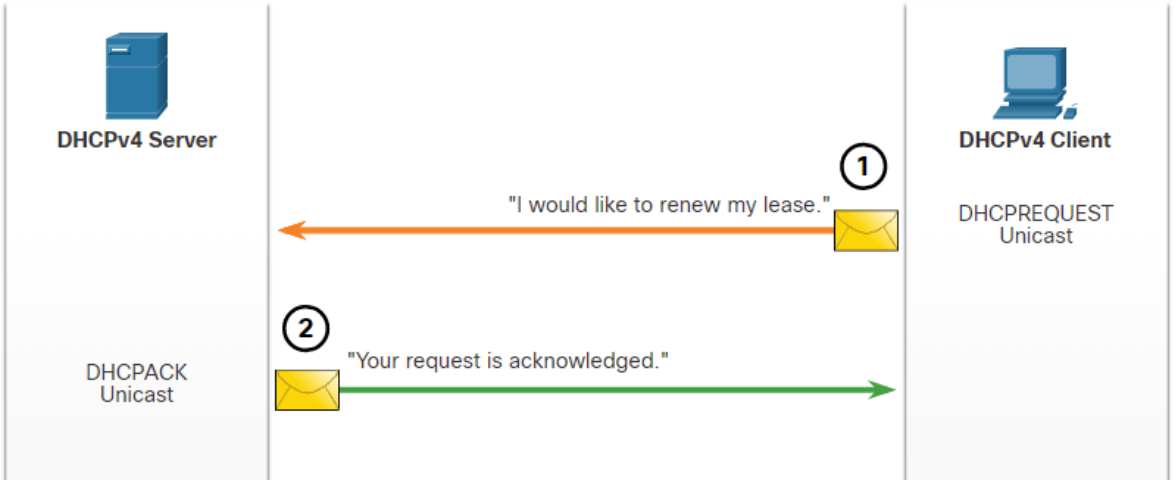


Steps to Renew a Lease

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.

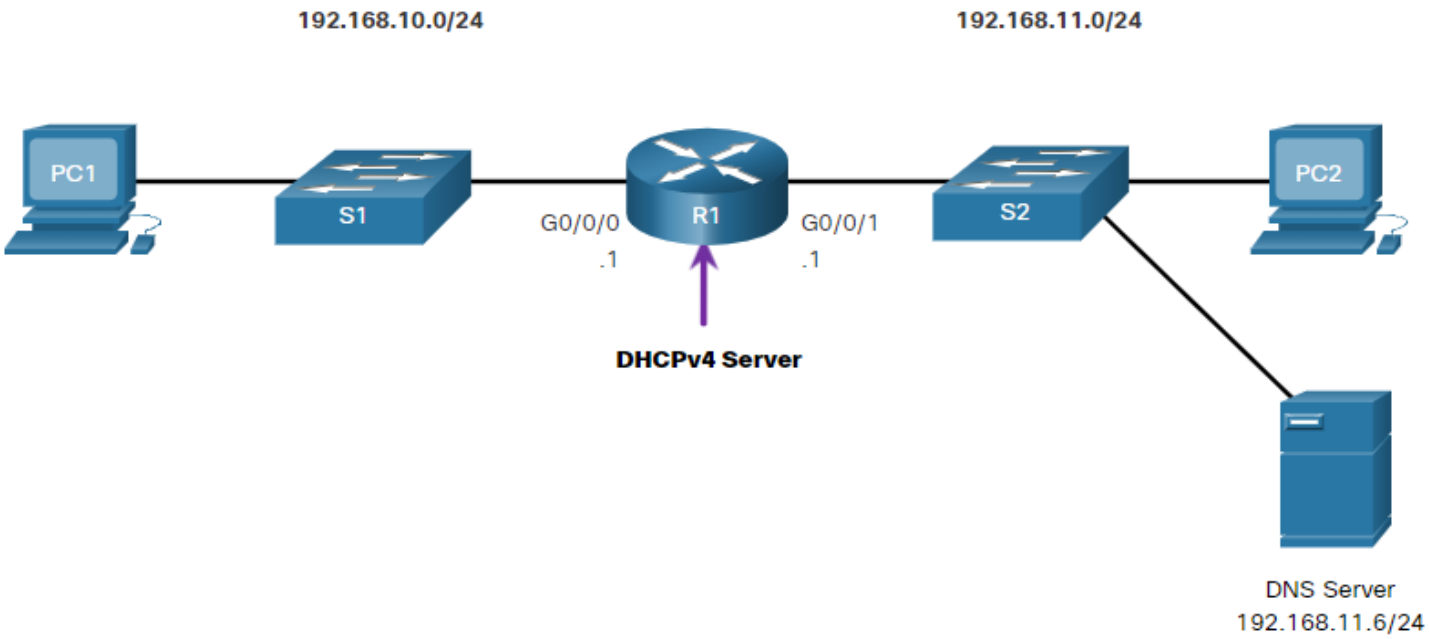


Note: These messages (primarily the DHCPOFFER and DHCPACK) can be sent as unicast or broadcast according to IETF RFC 2131.

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.



Steps to Configure a Cisco IOS DHCPv4 Server

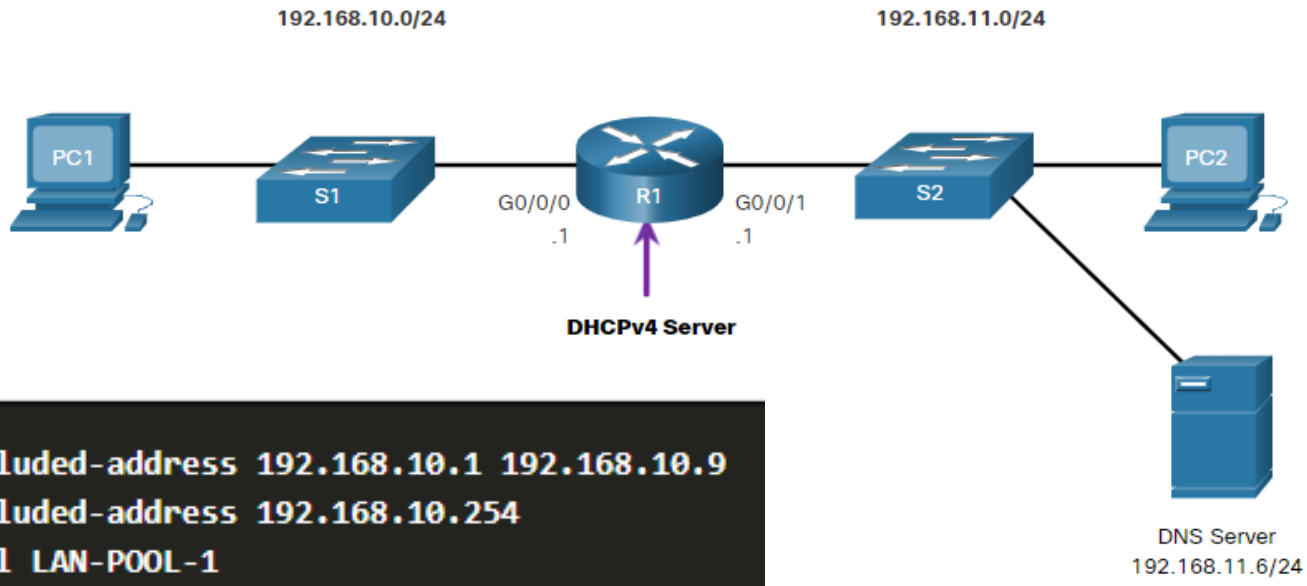
- Use the following steps to configure a Cisco IOS DHCPv4 server:
  - **Step 1**. Exclude IPv4 addresses. A single address or a range of addresses can be excluded by specifying the *low-address* and *high-address* of the range. Excluded addresses should be those addresses that are assigned to routers, 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)#.**

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** *network-number* [*mask* | / *prefix-length*]
Define the default router or gateway.	**default-router** address [*address2….address8*]
Define a DNS server.	**dns-server** *address* [*address2…address8*]
Define the domain name.	**domain-name** *domain*
Define the duration of the DHCP lease.	**lease** {*days* [*hours* [*minutes*]] | **infinite**}
Define the NetBIOS WINS server.	**netbios-name-server** *address* [*address2…address8*]

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#
```

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

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
```

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
```

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
DHCPINFORM           0
```

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
```

Disable the Cisco IOS DHCPv4 Server

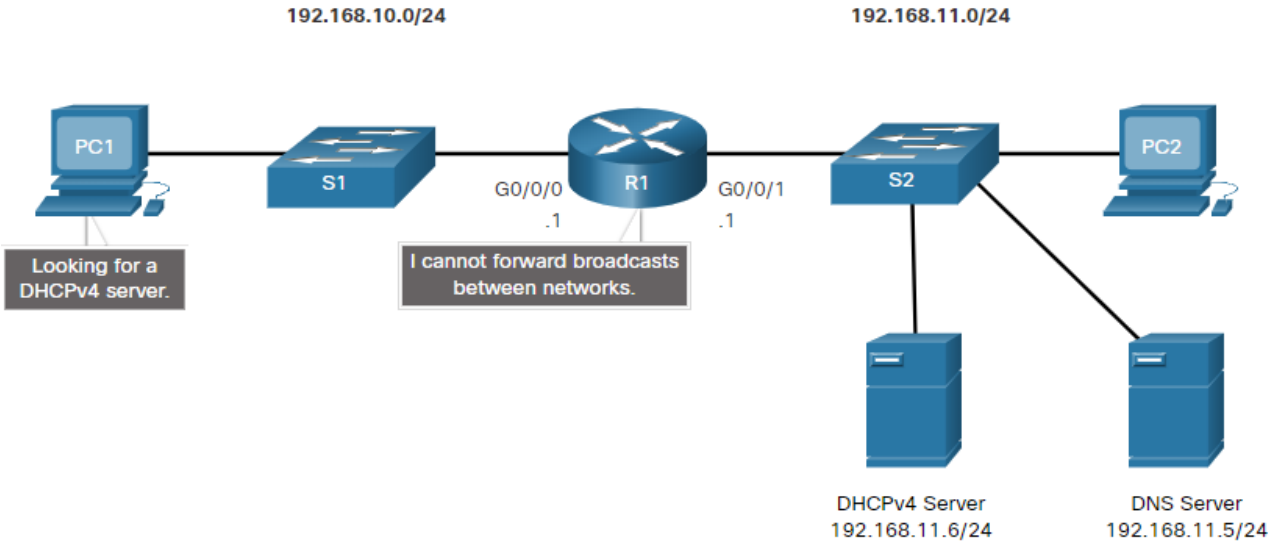
The DHCPv4 service is enabled by default. To disable the service, use the **no service dhcp** global configuration mode command. Use the **service dhcp** global configuration mode command to re-enable the DHCPv4 server process, as shown in the example. Enabling the service has no effect if the parameters 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)#
```

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.



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)
```

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:

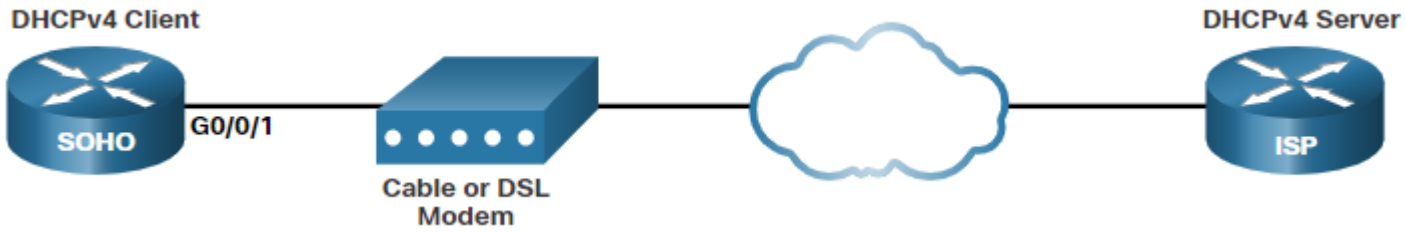
- Port 37: Time
- Port 49: TACACS
- Port 53: DNS
- Port 67: DHCP/BOOTP server
- Port 68: DHCP/BOOTP client
- Port 69: TFTP
- Port 137: NetBIOS name service
- Port 138: NetBIOS datagram service

Configure a 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
```

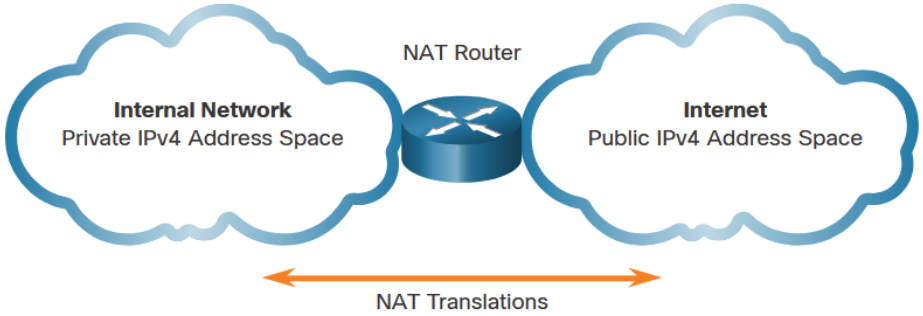
```
SOHO# show ip interface g0/0/1
GigabitEthernet0/0/1 is up, line protocol is up
  Internet address is 209.165.201.12/27
  Broadcast address is 255.255.255.255
  Address determined by DHCP
(output omitted)
```

NAT Characteristics

IPv4 Address Space

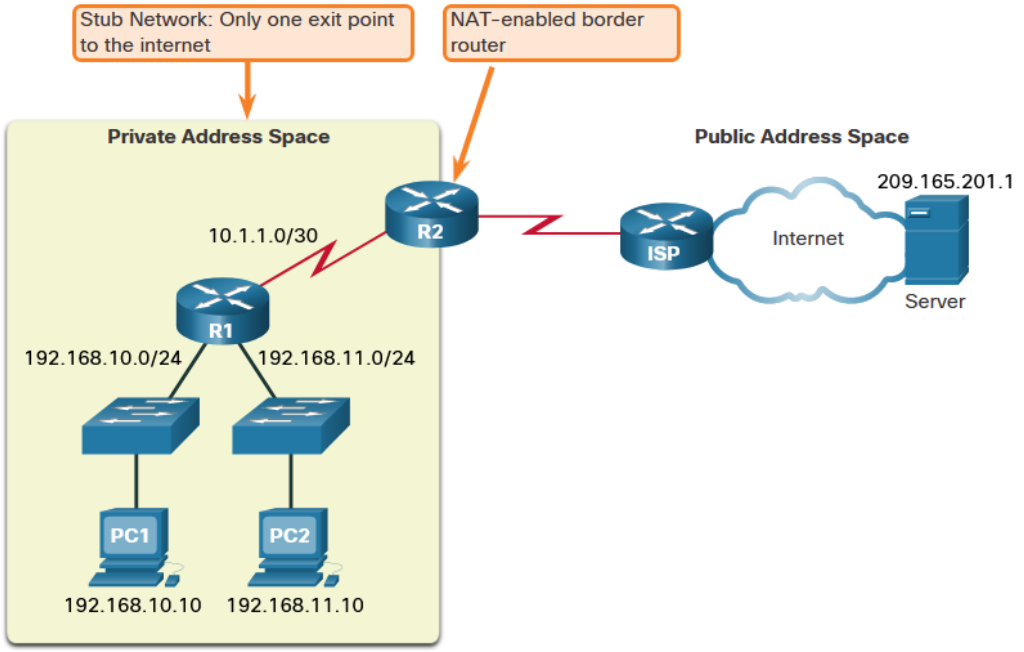
- Networks are commonly implemented using private IPv4 addresses, as defined in RFC 1918.
- Private IPv4 addresses cannot be routed over the internet and are used within an organization or site to allow devices to communicate locally.
- To allow a device with a private IPv4 address to access devices and resources outside of the local network, the private address must first be translated to a public address.
- NAT provides the translation of private addresses to public addresses.

Class	Activity Type	Activity Name
A	10.0.0.0 – 10.255.255.255	10.0.0.0/8
B	172.16.0.0 – 172.31.255.255	172.16.0.0/12
C	192.168.0.0 – 192.168.255.255	192.168.0.0/16



What is NAT

- The primary use of NAT is to conserve public IPv4 addresses.
- NAT allows networks to use private IPv4 addresses internally and translates them to a public address when needed.
- A NAT router typically operates at the border of a stub network.
- When a device inside the stub network wants to communicate with a device outside of its network, the packet is forwarded to the border router which performs the NAT process, translating the internal private address of the device to a public, outside, routable address.



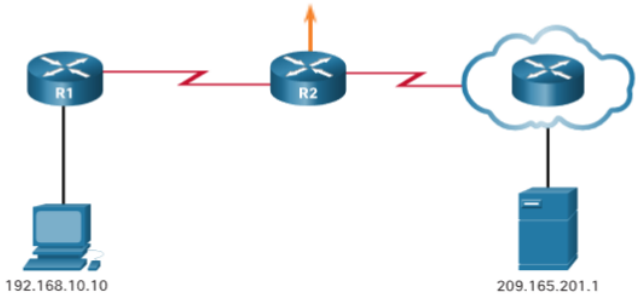
How NAT Works

PC1 wants to communicate with an outside web server with public address 209.165.201.1.

1. PC1 sends a packet addressed to the web server.
2. R2 receives the packet and reads the source IPv4 address to determine if it needs translation.
3. R2 adds mapping of the local to global address to the NAT table.
4. R2 sends the packet with the translated source address toward the destination.
5. The web server responds with a packet addressed to the inside global address of PC1 (209.165.200.226).
6. R2 receives the packet with destination address 209.165.200.226. R2 checks the NAT table and finds an entry for this mapping. R2 uses this information and translates the inside global address (209.165.200.226) to the inside local address (192.168.10.10), and the packet is forwarded toward PC1.

NAT Table

Inside Local	Inside Global	Outside Local	Outside Global
192.168.10.10	209.165.200.226	209.165.201.1	209.165.201.1



NAT Terminology

- NAT includes four types of addresses:
  - Inside local address
  - Inside global address
  - Outside local address
  - Outside global address
- NAT terminology is always applied from the perspective of the device with the translated address:
  - **Inside address** - The address of the device which is being translated by NAT.
  - **Outside address** - The address of the destination device.
  - **Local address** - A local address is any address that appears on the inside portion of the network.
  - **Global address** - A global address is any address that appears on the outside portion of the network.

NAT Terminology (Cont.)

Inside local address

The address of the source as seen from inside the network. This is typically a private IPv4 address. The inside local address of PC1 is 192.168.10.10.

Inside global addresses

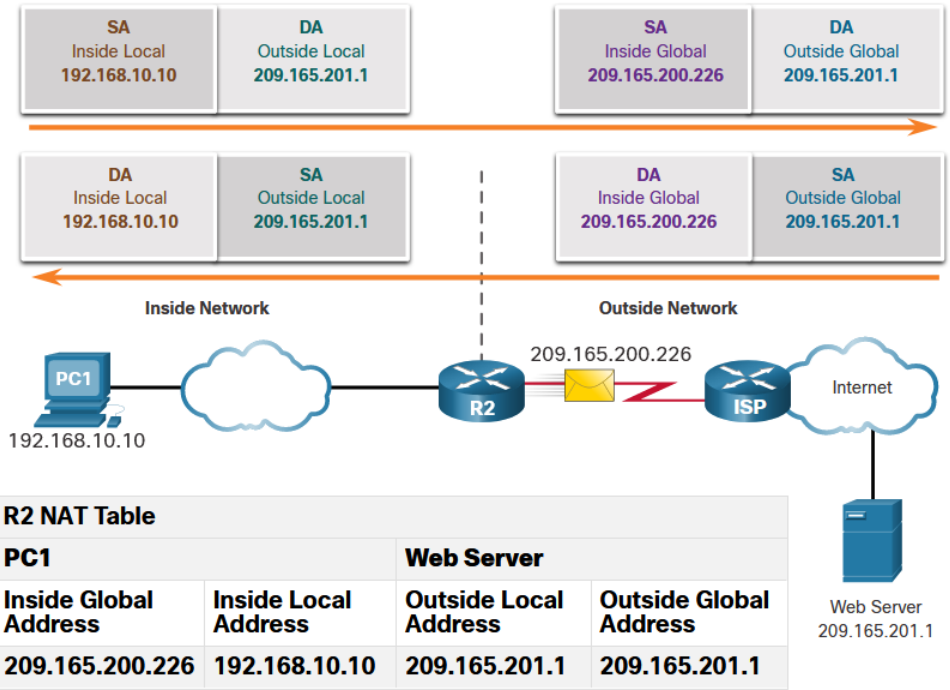
The address of source as seen from the outside network. The inside global address of PC1 is 209.165.200.226

Outside global address

The address of the destination as seen from the outside network. The outside global address of the web server is 209.165.201.1

Outside local address

The address of the destination as seen from the inside network. PC1 sends traffic to the web server at the IPv4 address 209.165.201.1. While uncommon, this address could be different than the globally routable address of the destination.



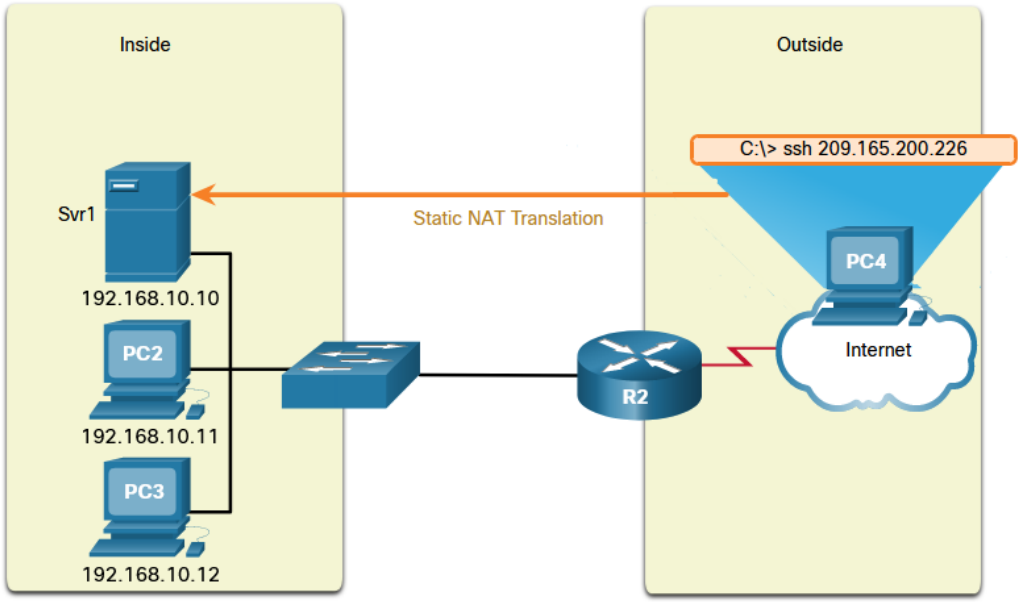
R2 NAT Table			
PC1		**Web Server**	
Inside Global Address	**Inside Local Address**	**Outside Local Address**	**Outside Global Address**
209.165.200.226	192.168.10.10	209.165.201.1	209.165.201.1

Types of NAT

Static NAT

Static NAT uses a one-to-one mapping of local and global addresses configured by the network administrator that remain constant.

- Static NAT is useful for web servers or devices that must have a consistent address that is accessible from the internet, such as a company web server.
- It is also useful for devices that must be accessible by authorized personnel when offsite, but not by the general public on the internet.



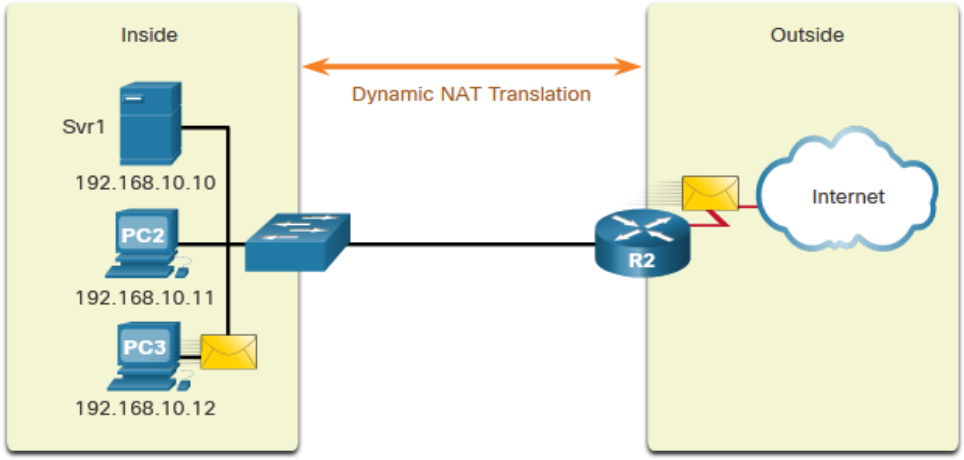
Static NAT Table	
Inside Local Address	**Inside Global Address - Addresses reachable via R2**
192.168.10.10	209.165.200.226
192.168.10.11	209.165.200.227
192.168.10.12	209.165.200.228

Note: Static NAT requires that enough public addresses are available to satisfy the total number of simultaneous user sessions.

Dynamic NAT

Dynamic NAT uses a pool of public addresses and assigns them on a first-come, first-served basis.

- When an inside device requests access to an outside network, dynamic NAT assigns an available public IPv4 address from the pool.
- The other addresses in the pool are still available for use.



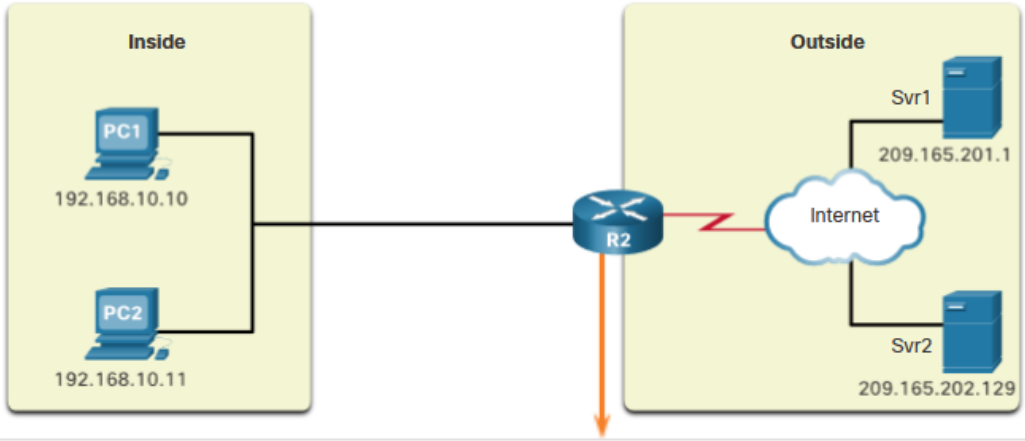
IPv4 NAT Pool	
Inside Local Address	**Inside Global Address Pool - Addresses reachable via R2**
192.168.10.12	209.165.200.226
Available	209.165.200.227
Available	209.165.200.228
Available	209.165.200.229
Available	209.165.200.230

Note: Dynamic NAT requires that enough public addresses are available to satisfy the total number of simultaneous user sessions.

Port Address Translation

Port Address Translation (PAT), also known as NAT overload, maps multiple private IPv4 addresses to a single public IPv4 address or a few addresses.

- With PAT, when the NAT router receives a packet from the client, it uses the source port number to uniquely identify the specific NAT translation.
- PAT ensures that devices use a different TCP port number for each session with a server on the internet.



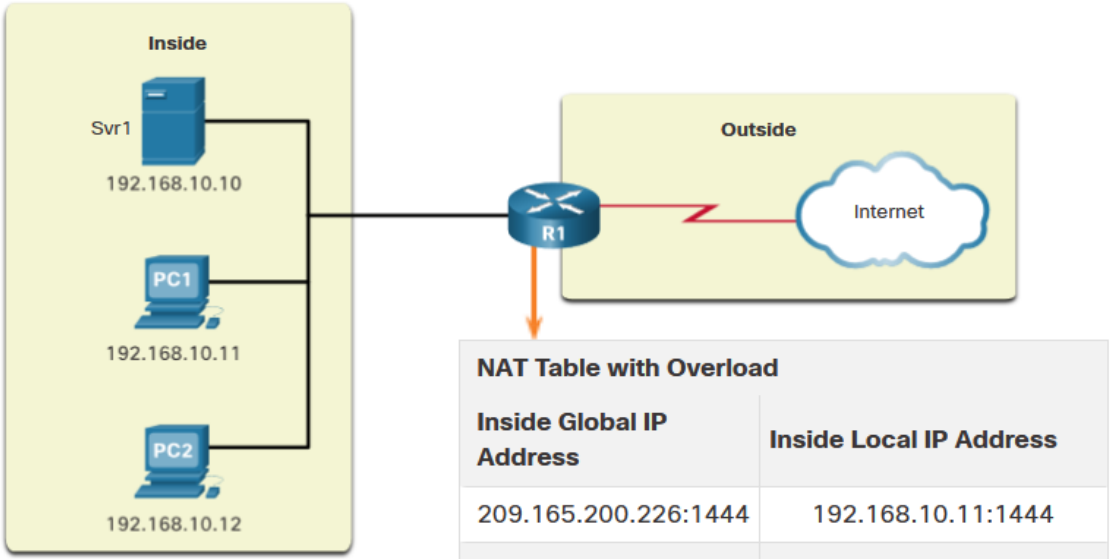
NAT Table with Overload

Inside Local IP Address	Inside Global IP Address	Outside Local IP Address	Outside Global IP Address
192.168.10.10:1555	209.165.200.226:1555	209.165.201.1:80	209.165.201.1:80
192.168.10.11:1331	209.165.200.226:1331	209.165.202.129:80	209.165.202.129:80

Next Available Port

PAT attempts to preserve the original source port. If the original source port is already used, PAT assigns the first available port number starting from the beginning of the appropriate port group 0-511, 512-1,023, or 1,024-65,535.

- When there are no more ports available and there is more than one external address in the address pool, PAT moves to the next address to try to allocate the original source port.
- The process continues until there are no more available ports or external IPv4 addresses in the address pool.



NAT Table with Overload

Inside Global IP Address	Inside Local IP Address
209.165.200.226:1444	192.168.10.11:1444
209.165.200.226:1445	192.168.10.12:1444

NAT and PAT Comparison

Summary of the differences between NAT and PAT.

NAT - Only modifies the IPv4 addresses

Inside Global Address	Inside Local Address
209.165.200.226	192.168.10.10

PAT - PAT modifies both the IPv4 address and the port number.

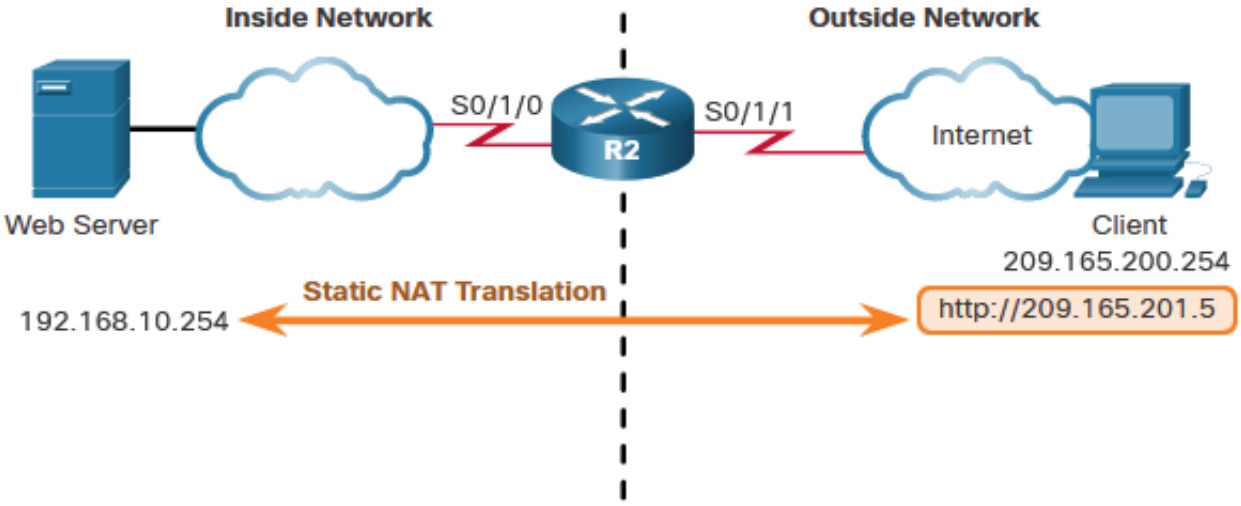
Inside Global Address	Inside Local Address
209.165.200.226:2031	192.168.10.10:2031

NAT	PAT
One-to-one mapping between Inside Local and Inside Global addresses.	One Inside Global address can be mapped to many Inside Local addresses.
Uses only IPv4 addresses in translation process.	Uses IPv4 addresses and TCP or UDP source port numbers in translation process.
A unique Inside Global address is required for each inside host accessing the outside network.	A single unique Inside Global address can be shared by many inside hosts accessing the outside network.

Static NAT

Static NAT Scenario

- Static NAT is a one-to-one mapping between an inside address and an outside address.
- Static NAT allows external devices to initiate connections to internal devices using the statically assigned public address.
- For instance, an internal web server may be mapped to a specific inside global address so that it is accessible from outside networks.



Configure Static NAT

There are two basic tasks when configuring static NAT translations:

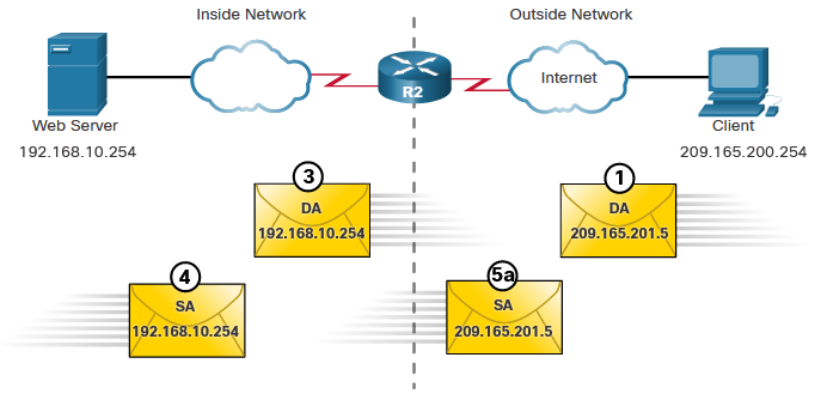
- **Step 1** - Create a mapping between the inside local address and the inside global addresses using the **ip nat inside source static** command.
- **Step 2** - The interfaces participating in the translation are configured as inside or outside relative to NAT with the **ip nat inside** and **ip nat outside** commands.

```
R2(config)# ip nat inside source static 192.168.10.254 209.165.201.5
R2(config)#
R2(config)# interface serial 0/1/0
R2(config-if)# ip address 192.168.1.2 255.255.255.252
R2(config-if)# ip nat inside
R2(config-if)# exit
R2(config)# interface serial 0/1/1
R2(config-if)# ip address 209.165.200.1 255.255.255.252
R2(config-if)# ip nat outside
```

Analyze Static NAT

The static NAT translation process between the client and the web server:

1. The client sends a packet to the web server.
2. R2 receives packets from the client on its NAT outside interface and checks its NAT table.
3. R2 translates the inside global address of to the inside local address and forwards the packet towards the web server.
4. The web server receives the packet and responds to the client using its inside local address.
5. (a) R2 receives the packet from the web server on its NAT inside interface with source address of the inside local address of the web server and (b) translates the source address to the inside global address.



	Inside Local Address	Inside Global Address	Outside Local Address	Outside Global Address
2 5b	192.168.10.254	209.165.201.5	209.165.200.254	209.165.200.254

Verify Static NAT

To verify NAT operation, issue the **show ip nat translations** command.

- This command shows active NAT translations.
- Because the example is a static NAT configuration, the translation is always present in the NAT table regardless of any active communications.
- If the command is issued during an active session, the output also indicates the address of the outside device.

```
R2# show ip nat translations
Pro  Inside global       Inside local       Outside local      Outside global
---  209.165.201.5       192.168.10.254     ---                ---
Total number of translations: 1
```

```
R2# show ip nat translations
Pro  Inside global       Inside local       Outside local         Outside global
tcp  209.165.201.5       192.168.10.254     209.165.200.254       209.165.200.254
---  209.165.201.5       192.168.10.254       ---                   ---
Total number of translations: 2
```

Verify Static NAT (Cont.)

Another useful command is **show ip nat statistics.**

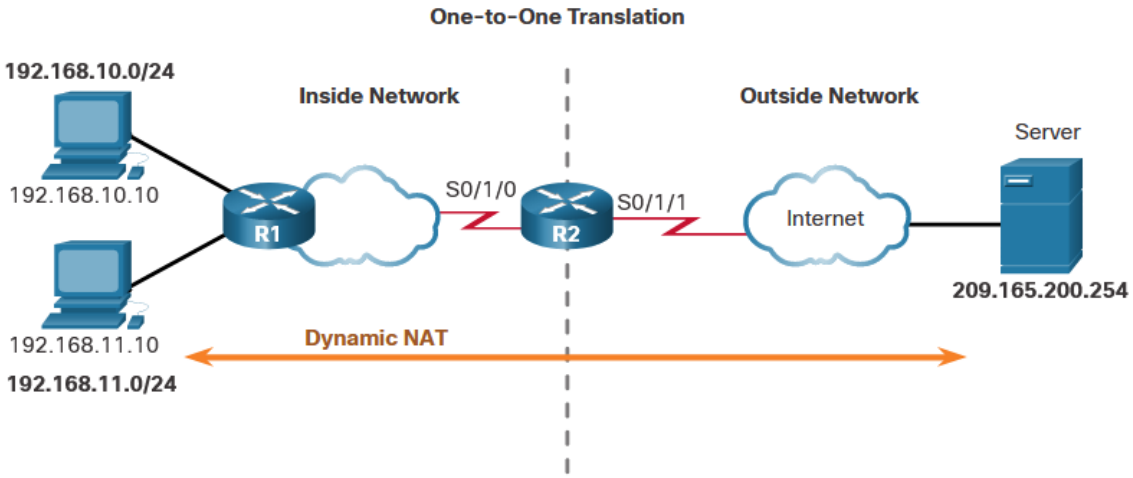
- It displays information about the total number of active translations, NAT configuration parameters, the number of addresses in the pool, and the number of addresses that have been allocated.
- To verify that the NAT translation is working, it is best to clear statistics from any past translations using the **clear ip nat statistics** command before testing.

```
R2# show ip nat statistics
Total active translations: 1 (1 static, 0 dynamic; 0 extended)
Outside interfaces:
  Serial0/1/1
Inside interfaces:
  Serial0/1/0
Hits: 4  Misses: 1
(output omitted)
```

Dynamic NAT

Dynamic NAT Scenario

- Dynamic NAT automatically maps inside local addresses to inside global addresses.
- Dynamic NAT uses a pool of inside global addresses.
- The pool of inside global addresses is available to any device on the inside network on a first-come first-served basis.
- If all addresses in the pool are in use, a device must wait for an available address before it can access the outside network.



Configure Dynamic NAT

There are five tasks when configuring dynamic NAT translations:

- **Step 1** - Define the pool of addresses that will be used for translation using the **ip nat pool** command.
- **Step 2** - Configure a standard ACL to identify (permit) only those addresses that are to be translated.
- **Step 3** - Bind the ACL to the pool, using the **ip nat inside source list** command.

```
R2(config)# ip nat pool NAT-POOL1 209.165.200.226 209.165.200.240 netmask 255.255.255.224
R2(config)# access-list 1 permit 192.168.0.0 0.0.255.255
R2(config)# ip nat inside source list 1 pool NAT-POOL1
```

Configure Dynamic NAT (Cont.)

There are five tasks when configuring dynamic NAT translations:

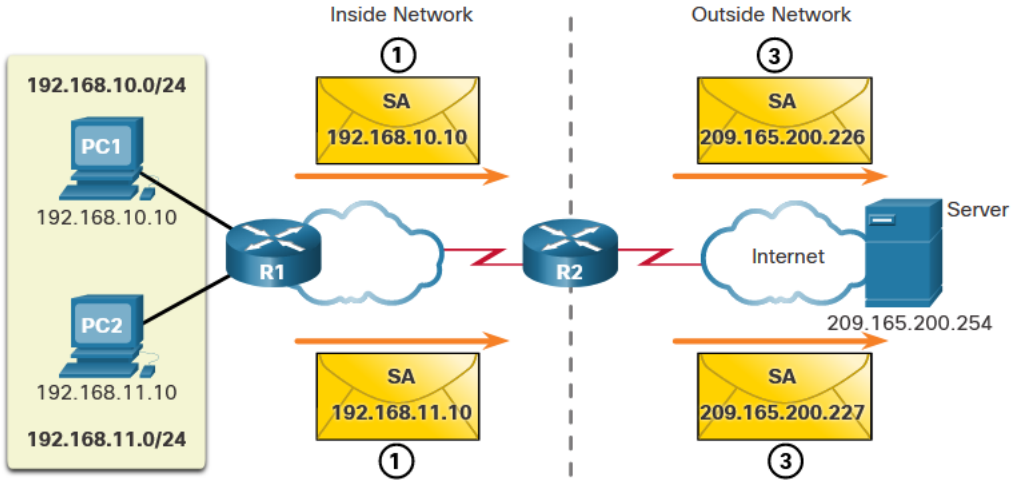
- **Step 4** - Identify which interfaces are inside.
- **Step 5** - Identify which interfaces are outside.

```
R2(config)# ip nat pool NAT-POOL1 209.165.200.226 209.165.200.240 netmask 255.255.255.224
R2(config)# access-list 1 permit 192.168.0.0 0.0.255.255
R2(config)# ip nat inside source list 1 pool NAT-POOL1
R2(config)# interface serial 0/1/0
R2(config-if)# ip nat inside
R2(config-if)# interface serial 0/1/1
R2(config-if)# ip nat outside
```

Analyze Dynamic NAT – Inside to Outside

Dynamic NAT translation process:

1. PC1 and PC2 send packets requesting a connection to the server.
2. R2 receives the first packet from PC1, checks the ALC to determine if the packet should be translated, selects an available global address, and creates a translation entry in the NAT table.
3. R2 replaces the inside local source address of PC1, 192.168.10.10, with the translated inside global address of 209.165.200.226 and forwards the packet. (The same process occurs for the packet from PC2 using the translated address of 209.165.200.227.)



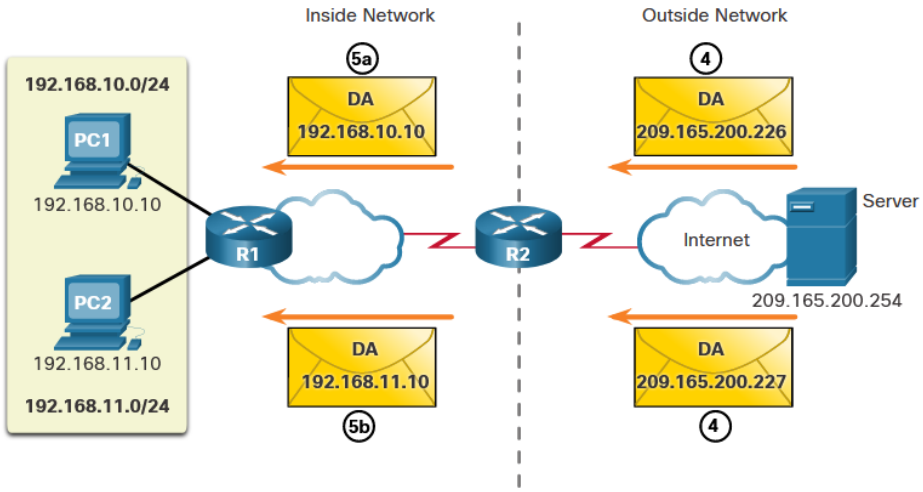
IPv4 NAT Pool	
Inside Local Address Pool	**Inside Global Address**
192.168.10.10	209.165.200.226
192.168.11.10	209.165.200.227

Analyze Dynamic NAT – Outside to Inside

Dynamic NAT translation process:

4. The server receives the packet from PC1 and responds using the destination address of 209.165.200.226. The server receives the packet from PC2, it responds to using the destination address of 209.165.200.227.

5. (a) When R2 receives the packet with the destination address of 209.165.200.226; it performs a NAT table lookup and translates the address back to the inside local address and forwards the packet toward PC1.
   (b) When R2 receives the packet with the destination address of 209.165.200.227; it performs a NAT table lookup and translates the address back to the inside local address 192.168.11.10 and forwards the packet toward PC2.

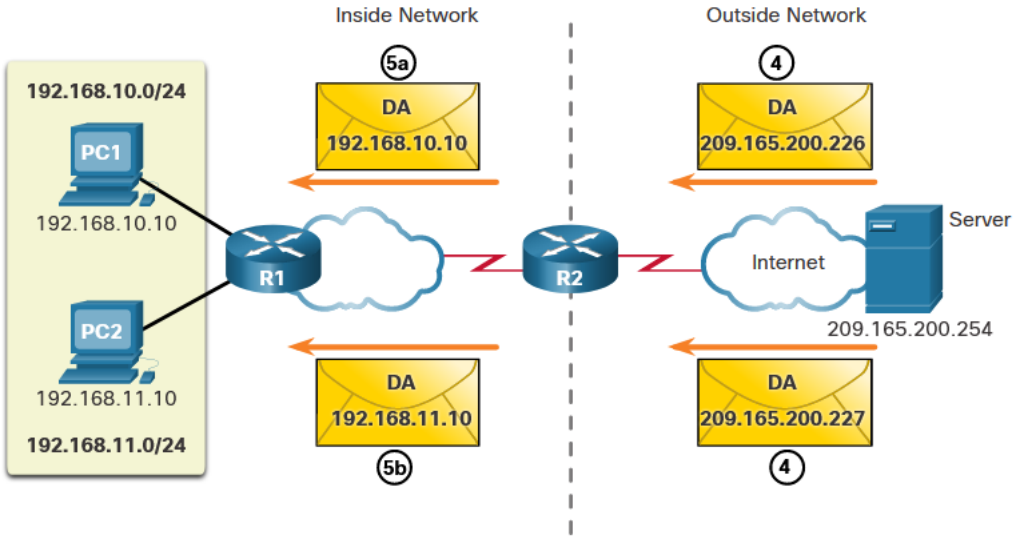


	IPv4 NAT Pool	
	Inside Local Address Pool	**Inside Global Address**
5a	192.168.10.10	209.165.200.226
5b	192.168.11.10	209.165.200.227

Analyze Dynamic NAT – Outside to Inside (Cont.)

Dynamic NAT translation process:

6. PC1 and PC2 receive the packets and continue the conversation. The router performs Steps 2 to 5 for each packet.



	IPv4 NAT Pool	
	Inside Local Address Pool	**Inside Global Address**
5a	192.168.10.10	209.165.200.226
5b	192.168.11.10	209.165.200.227

Verify Dynamic NAT

The output of the **show ip nat translations** command displays all static translations that have been configured and any dynamic translations that have been created by traffic.

```
R2# show ip nat translations
Pro  Inside global     Inside local       Outside local      Outside global
---  209.165.200.228   192.168.10.10      ---                ---
---  209.165.200.229   192.168.11.10      ---                ---
R2#
```

Verify Dynamic NAT (Cont.)

Adding the **verbose** keyword displays additional information about each translation, including how long ago the entry was created and used.

```
R2# show ip nat translation verbose
Pro Inside global      Inside local       Outside local      Outside global
tcp 209.165.200.228    192.168.10.10      ---                ---
    create 00:02:11, use 00:02:11 timeout:86400000, left 23:57:48, Map-Id(In): 1,
    flags:
none, use_count: 0, entry-id: 10, lc_entries: 0
tcp 209.165.200.229    192.168.11.10      ---                ---
    create 00:02:10, use 00:02:10 timeout:86400000, left 23:57:49, Map-Id(In): 1,
    flags:
none, use_count: 0, entry-id: 12, lc_entries: 0
R2#
```

Verify Dynamic NAT (Cont.)

By default, translation entries time out after 24 hours, unless the timers have been reconfigured with the **ip nat translation timeout** *timeout-seconds* command in global configuration mode. To clear dynamic entries before the timeout has expired, use the **clear ip nat translation** privileged EXEC mode command.

```
R2# clear ip nat translation *
R2# show ip nat translation
```

Command	Description
clear ip nat translation *	Clears all dynamic address translation entries from the NAT translation table.
clear ip nat translation inside *global-ip local-ip* [**outside** *local-ip global-ip*]	Clears a simple dynamic translation entry containing an inside translation or both inside and outside translation.
clear ip nat translation *protocol* **inside** *global-ip global-port local-ip local-port* [**outside** *local-ip local-port global-ip global-port*]	Clears an extended dynamic translation entry.

Verify Dynamic NAT (Cont.)

The **show ip nat statistics** command displays information about the total number of active translations, NAT configuration parameters, the number of addresses in the pool, and how many of the addresses have been allocated.

```
R2# show ip nat statistics
Total active translations: 4 (0 static, 4 dynamic; 0 extended)
Peak translations: 4, occurred 00:31:43 ago
Outside interfaces:
  Serial0/1/1
Inside interfaces:
  Serial0/1/0
Hits: 47  Misses: 0
CEF Translated packets: 47, CEF Punted packets: 0
Expired translations: 5
Dynamic mappings:
-- Inside Source
[Id: 1] access-list 1 pool NAT-POOL1 refcount 4
 pool NAT-POOL1: netmask 255.255.255.224
         start 209.165.200.226 end 209.165.200.240
         type generic, total addresses 15, allocated 2 (13%), misses 0
(output omitted)
R2#
```

Verify Dynamic NAT (Cont.)

The **show running-config** command and show s the NAT, ACL, interface, or pool commands with the required values.

```
R2# show running-config | include NAT
ip nat pool NAT-POOL1 209.165.200.226 209.165.200.240 netmask 255.255.255.224
ip nat inside source list 1 pool NAT-POOL1
```

PAT

PAT

Configure PAT to Use a Single IPv4 Address

To configure PAT to use a single IPv4 address, add the keyword **overload** to the **ip nat inside source** command.

In the example, all hosts from network 192.168.0.0/16 (matching ACL 1) that send traffic through router R2 to the internet will be translated to IPv4 address 209.165.200.225 (IPv4 address of interface S0/1/1). The traffic flows will be identified by port numbers in the NAT table because the **overload** keyword is configured.

```
R2(config)# ip nat inside source list 1 interface serial 0/1/0 overload
R2(config)# access-list 1 permit 192.168.0.0 0.0.255.255
R2(config)# interface serial0/1/0
R2(config-if)# ip nat inside
R2(config-if)# exit
R2(config)# interface Serial0/1/1
R2(config-if)# ip nat outside
```

PAT

Configure PAT to Use an Address Pool

An ISP may allocate more than one public IPv4 address to an organization. In this scenario the organization can configure PAT to use a pool of IPv4 public addresses for translation.

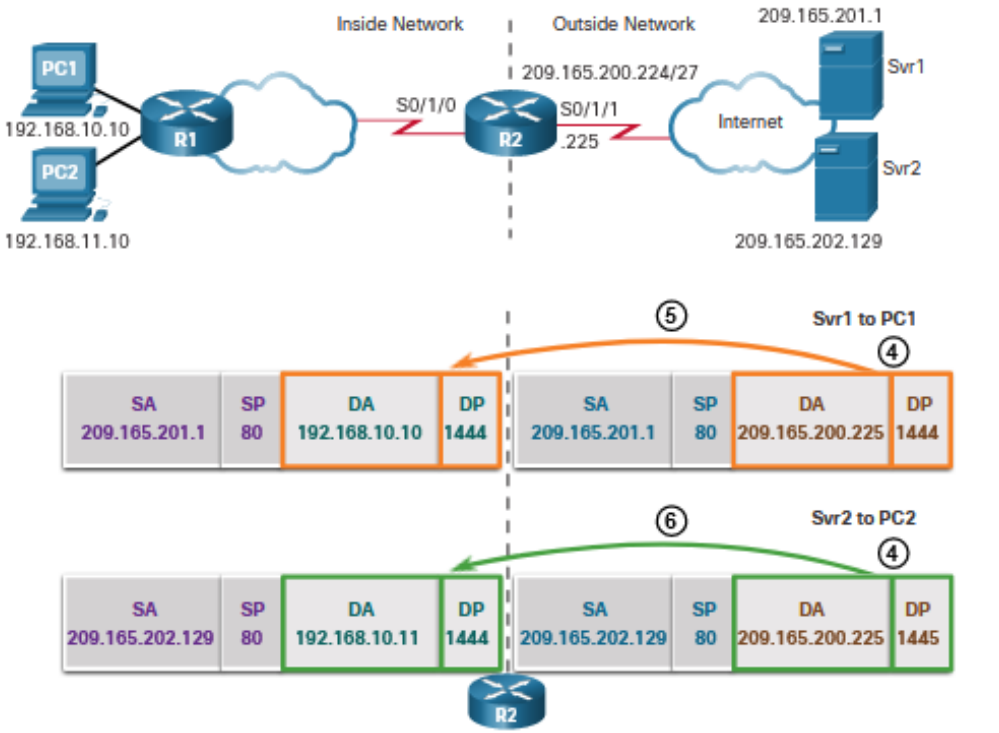
To configure PAT for a dynamic NAT address pool, simply add the keyword **overload** to the **ip nat inside source** command.

In the example, NAT-POOL2 is bound to an ACL to permit 192.168.0.0/16 to be translated. These hosts can share an IPv4 address from the pool because PAT is enabled with the keyword **overload**.

```
R2(config)# ip nat pool NAT-POOL2 209.165.200.226 209.165.200.240 netmask 255.255.255.224
R2(config)# access-list 1 permit 192.168.0.0 0.0.255.255
R2(config)# ip nat inside source list 1 pool NAT-POOL2 overload
R2(config)# interface serial0/1/0
R2(config-if)# ip nat inside
R2(config-if)# interface serial0/1/0
R2(config-if)# ip nat outside
```

Analyze PAT – Server to PC

1. PC1 and PC2 send packets to Svr1 and Svr2.
2. The packet from PC1 reaches R2 first. R2 modifies the source IPv4 address to 209.165.200.225 (inside global address). The packet is then forwarded towards Svr1.
3. The packet from PC2 arrives at R2. PAT changes the source IPv4 address of PC2 to the inside global address 209.165.200.225. PC2 has the same source port number as the translation for PC1. PAT increments the source port number until it is a unique value in its table. In this instance, 1445.

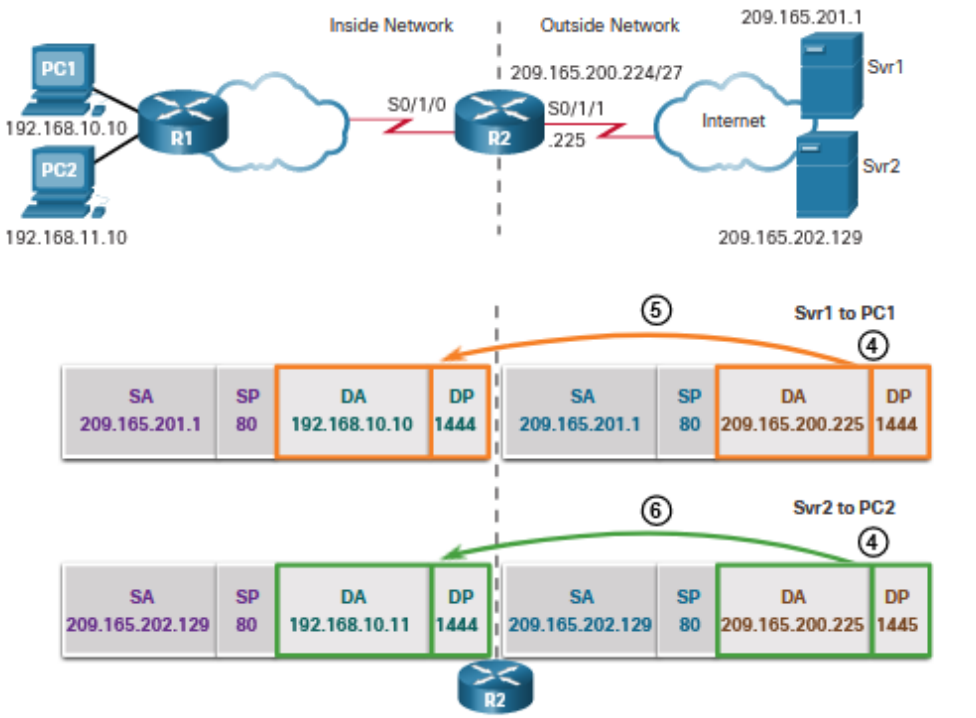


NAT Table

Inside Local Address	Inside Global Address	Outside Global Address	Outside Local Address
192.168.10.10:1444	209.165.200.225:1444	209.165.201.1:80	209.165.201.1:80
192.168.10.11:1444	209.165.200.225:1445	209.165.201.129:80	209.165.202.129:80

Analyze PAT – PC to Server

1. PC1 and PC2 send packets to Svr1 and Svr2.
2. The packet from PC1 reaches R2 first. R2 modifies the source IPv4 address to 209.165.200.225 (inside global address). The packet is then forwarded towards Svr1.
3. The packet from PC2 arrives at R2. PAT changes the source IPv4 address of PC2 to the inside global address 209.165.200.225. PC2 has the same source port number as the translation for PC1. PAT increments the source port number until it is a unique value in its table. In this instance, it is 1445.

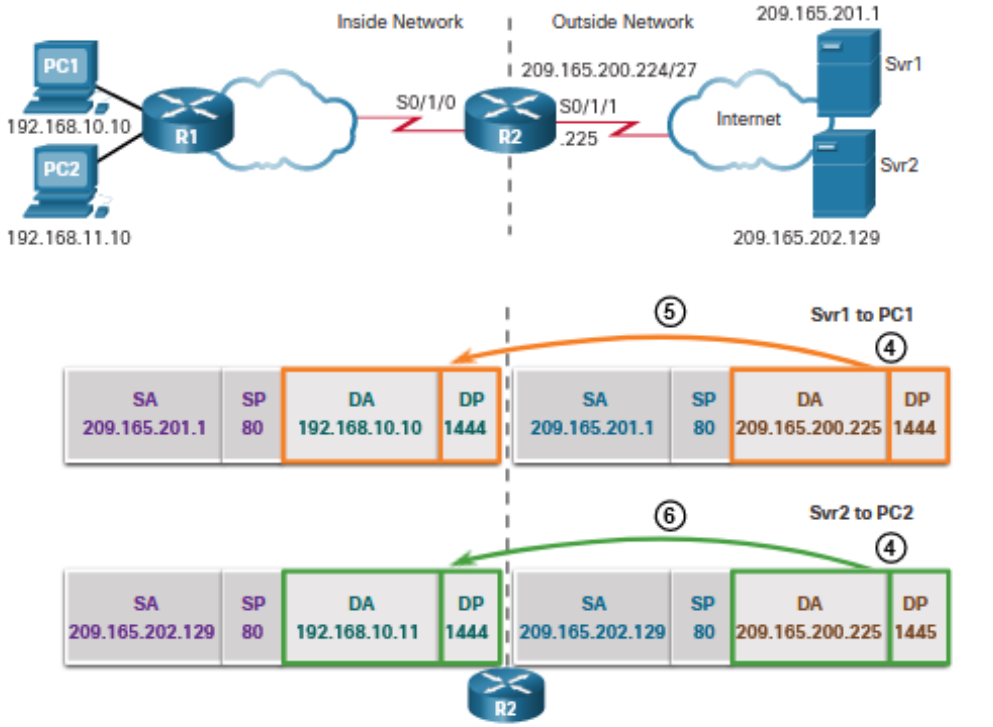


NAT Table

Inside Local Address	Inside Global Address	Outside Global Address	Outside Local Address
192.168.10.10:1444	209.165.200.225:1444	209.165.201.1:80	209.165.201.1:80
192.168.10.11:1444	209.165.200.225:1445	209.165.201.129:80	209.165.202.129:80

Analyze PAT – Server to PC

1. The servers use the source port from the received packet as the destination port, and the source address as the destination address for the return traffic.
2. R2 changes the destination IPv4 address of the packet from Srv1 from 209.165.200.225 to 192.168.10.10, and forwards the packet toward PC1.
3. R2 changes the destination address of packet from Srv2. from 209.165.200.225 to 192.168.10.11. and modifies the destinations port back to its original value of 1444. The packet is then forwarded toward PC2.



NAT Table

Inside Local Address	Inside Global Address	Outside Global Address	Outside Local Address
192.168.10.10:1444	209.165.200.225:1444	209.165.201.1:80	209.165.201.1:80
192.168.10.11:1444	209.165.200.225:1445	209.165.201.129:80	209.165.202.129:80

Verify PAT

The same commands used to verify static and dynamic NAT are used to verify PAT. The **show ip nat translations** command displays the translations from two different hosts to different web servers. Notice that two different inside hosts are allocated the same IPv4 address of 209.165.200.226 (inside global address). The source port numbers in the NAT table differentiate the two transactions.

```
R2# show ip nat translations
Pro Inside global          Inside local         Outside local      Outside global
tcp 209.165.200.225:1444  192.168.10.10:1444  209.165.201.1:80   209.165.201.1:80
tcp 209.165.200.225:1445  192.168.11.10:1444  209.165.202.129:80 209.165.202.129:80
R2#
```

PAT

Verify PAT (Cont.)

The **show ip nat statistics** command verifies that NAT-POOL2 has allocated a single address for both translations. Also shown are the number and type of active translations, NAT configuration parameters, the number of addresses in the pool, and how many have been allocated.

```
R2# show ip nat statistics
Total active translations: 4 (0 static, 2 dynamic; 2 extended)
Peak translations: 2, occurred 00:31:43 ago
Outside interfaces:
  Serial0/1/1
Inside interfaces:
  Serial0/1/0
Hits: 4  Misses: 0
CEF Translated packets: 47, CEF Punted packets: 0
Expired translations: 0
Dynamic mappings:
-- Inside Source
[Id: 3] access-list 1 pool NAT-POOL2 refcount 2
 pool NAT-POOL2: netmask 255.255.255.224
         start 209.165.200.225 end 209.165.200.240
         type generic, total addresses 15, allocated 1 (6%), misses 0
(output omitted)
R2#
```

Today end, **See you next week!**