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Unit10 NAT for IPv4

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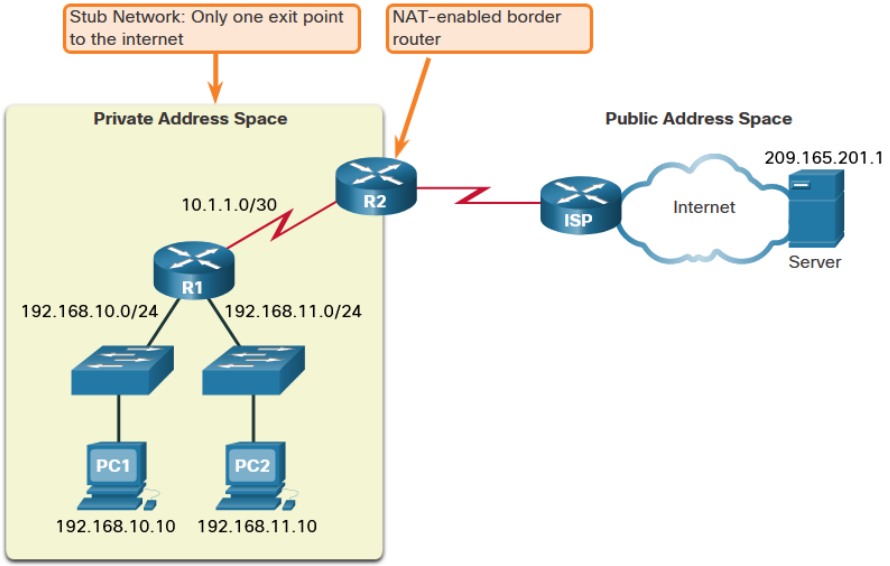
10.1 NAT Characteristics

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.



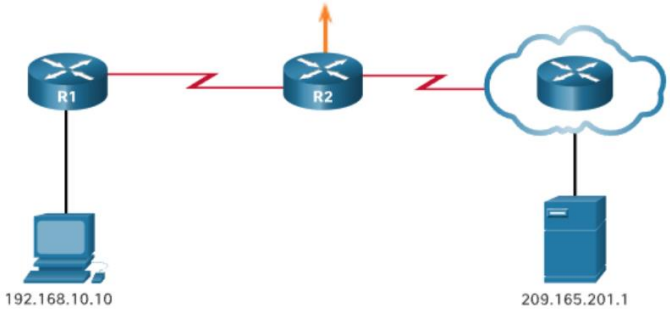
How NAT Works

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

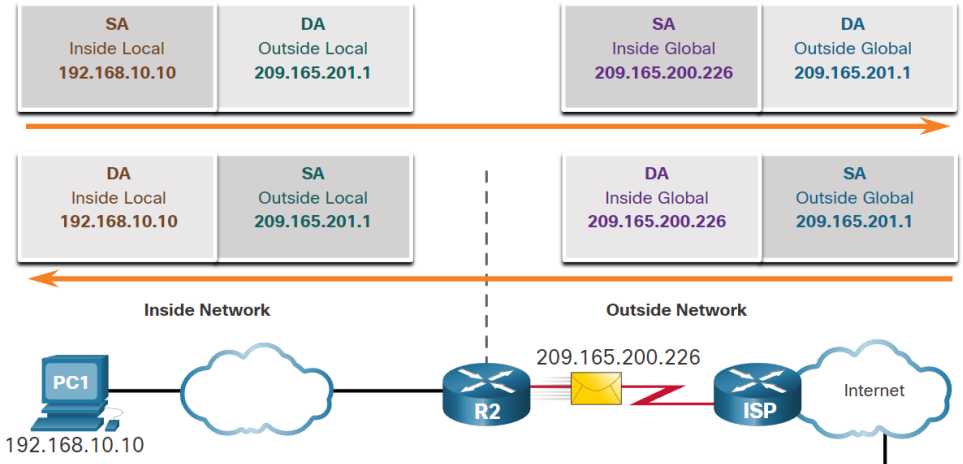
Inside Local	Inside Global	Outside Local	Outside Global
192.168.10.10	209.165.200.226	209.165.201.1	209.165.201.1



NAT Terminology

NAT terminology is always applied from the perspective of the device with the translated address:

- **Inside address**
- **Outside address**
- **Local address**
- **Global address**



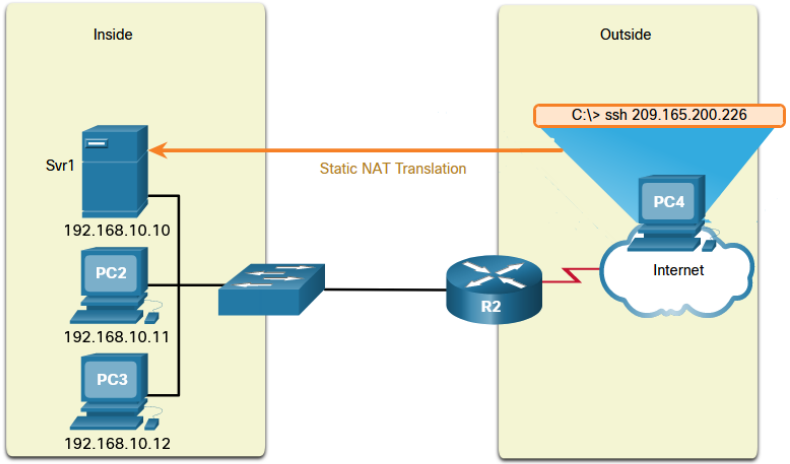
R2 NAT Table			
PC1		Web Server	
Inside Global Address	Inside Local Address	Outside Local Address	Outside Global Address
209.165.200.226	192.168.10.10	209.165.201.1	209.165.201.1

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.

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



Static NAT Table

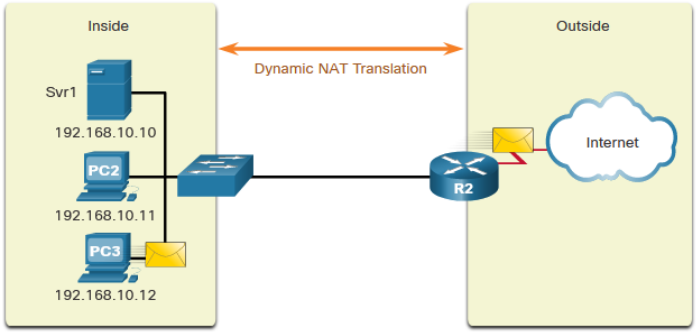
Inside Local Address	Inside Global Address - Addresses reachable via R2
192.168.10.10	209.165.200.226
192.168.10.11	209.165.200.227
192.168.10.12	209.165.200.228

Types of NAT : 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.

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

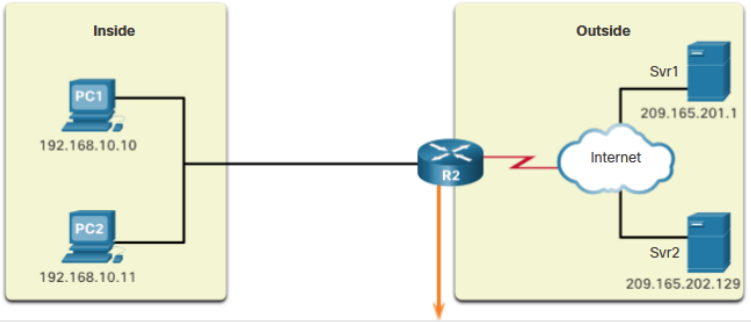


IPv4 NAT Pool	
Inside Local Address	**Inside Global Address Pool - Addresses reachable via R2**
192.168.10.12	209.165.200.226
Available	209.165.200.227
Available	209.165.200.228
Available	209.165.200.229
Available	209.165.200.230

Types of NAT: 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.



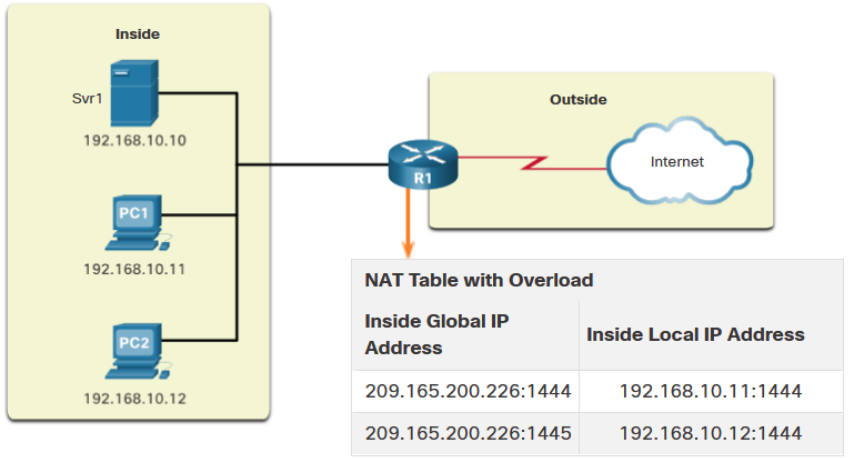
NAT Table with Overload

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.



Advantages of NAT

NAT provides many benefits:

- NAT conserves the legally registered addressing scheme by allowing the privatization of intranets.
- NAT conserves addresses through application port-level multiplexing.
- NAT increases the flexibility of connections to the public network.
- NAT provides consistency for internal network addressing schemes.
- NAT allows the existing private IPv4 address scheme to remain while allowing for easy change to a new public addressing scheme.
- NAT hides the IPv4 addresses of users and other devices.

Disadvantages of NAT

NAT does have drawbacks:

- NAT increases forwarding delays.
- End-to-end addressing is lost.
- End-to-end IPv4 traceability is lost.
- NAT complicates the use of tunneling protocols, such as IPsec.
- Services that require the initiation of TCP connections from the outside network, or stateless protocols, such as those using UDP, can be disrupted.

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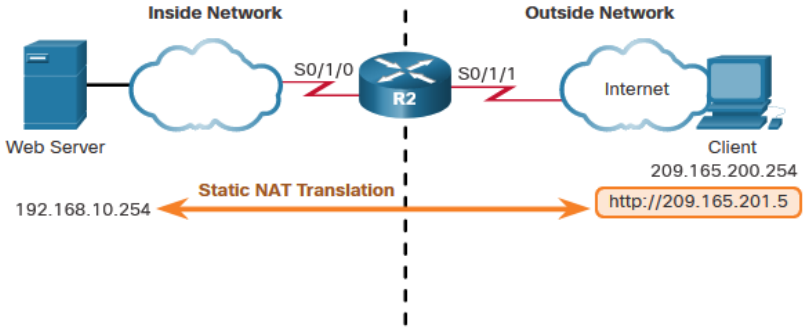
10.2 NAT Configuration

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:

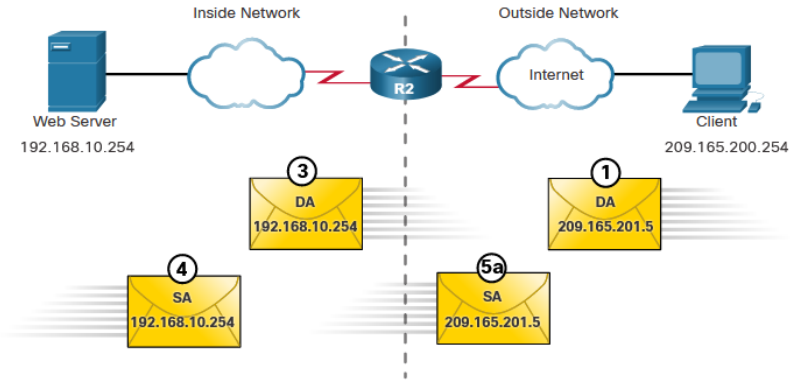
- **Step 1** - Create a mapping between the inside local address and the inside global addresses using the **ip nat inside source static** command.
- **Step 2** - The interfaces participating in the translation are configured as inside or outside relative to NAT with the **ip nat inside** and **ip nat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

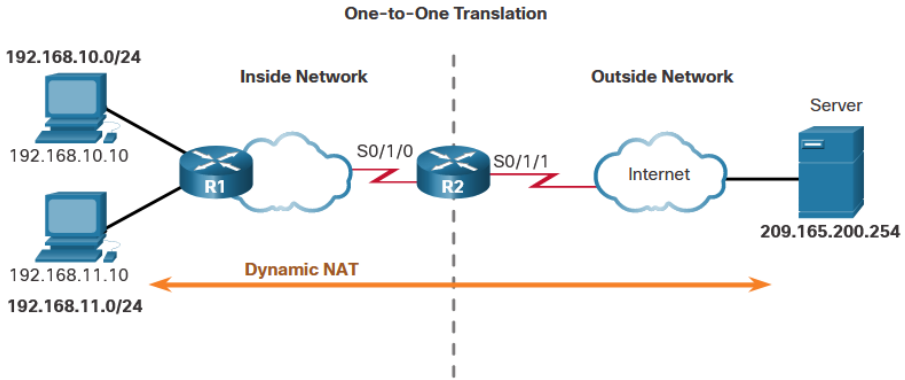
- Another useful command is **show ip nat statistics.**It displays information about the total number of active translations, NAT configuration parameters, the number of addresses in the pool, and the number of addresses that have been allocated.
- After the client establishes a session with the web server, the show ip nat statistics displays an increase to four hits on the inside (Serial0/1/0) interface. This verifies that the static NAT translation is taking place on R2.

```
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: 0  Misses: 0
(output omitted)
```

```
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 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

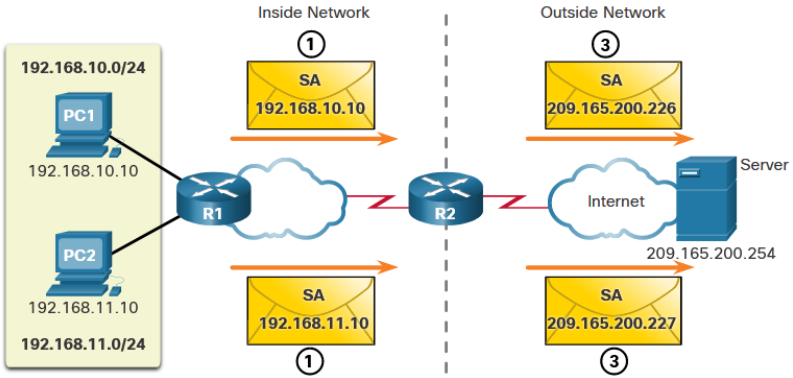
There are five tasks when configuring dynamic NAT translations:

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

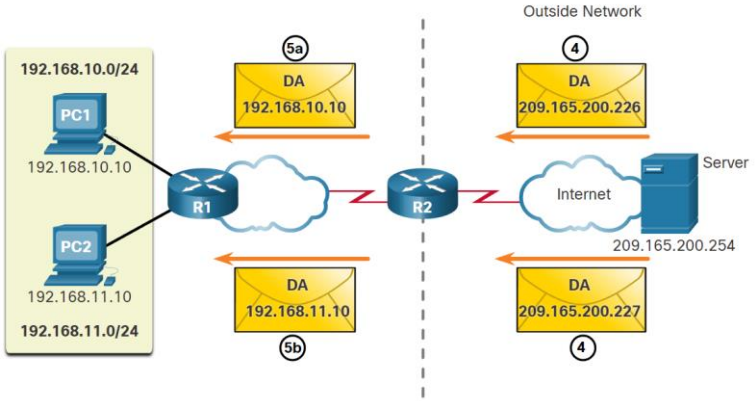
```
R2(config)# ip nat pool NAT-POOL1 209.165.200.226 209.165.200.240 netmask 255.255.255.224
R2(config)# access-list 1 permit 192.168.0.0 0.0.255.255
R2(config)# ip nat inside source list 1 pool NAT-POOL1
R2(config)# interface serial 0/1/0
R2(config-if)# ip nat inside
R2(config)# interface serial 0/1/1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

Analyze Dynamic NAT

Dynamic NAT translation process:



IPv4 NAT Pool	
Inside Local Address Pool	**Inside Global Address**
② 192.168.10.10	209.165.200.226
② 192.168.11.10	209.165.200.227



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.

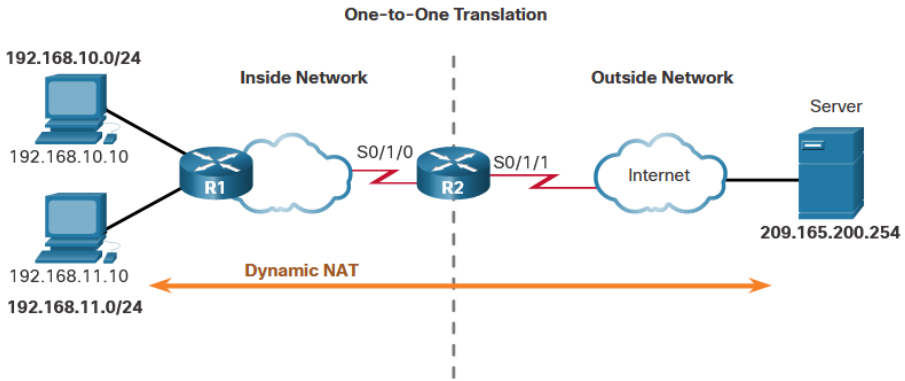
```
R2# show ip nat translations
Pro Inside global      Inside local       Outside local      Outside global
--- 209.165.200.228    192.168.10.10      ---                ---
--- 209.165.200.229    192.168.11.10      ---                ---
R2#
```

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

```
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 Scenario

- One Inside Global address can be mapped to many Inside Local addresses.
- Uses IPv4 addresses and TCP or UDP source port numbers in translation process.
- A single unique Inside Global address can be shared by many inside hosts accessing the outside network.



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.

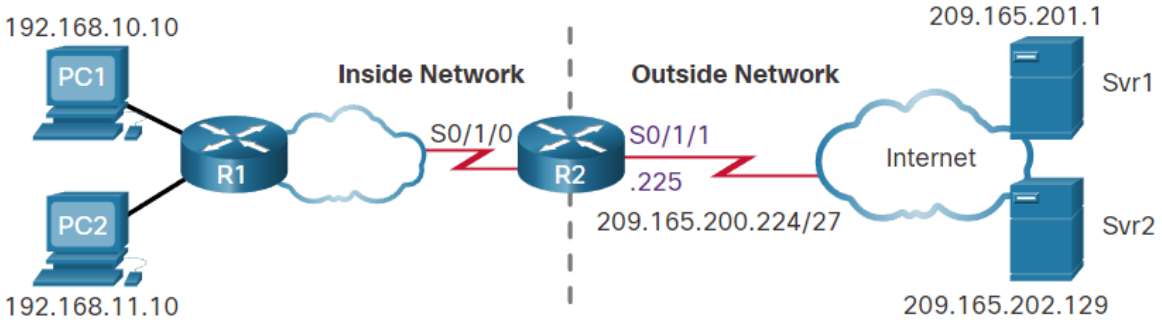
In the example, all hosts from network 192.168.0.0/16 (matching ACL 1) that send traffic through router R2 to the internet will be translated to IPv4 address 209.165.200.225 (IPv4 address of interface S0/1/1). The traffic flows will be identified by port numbers in the NAT table because the **overload**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

Configure PAT to Use an Address Pool

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

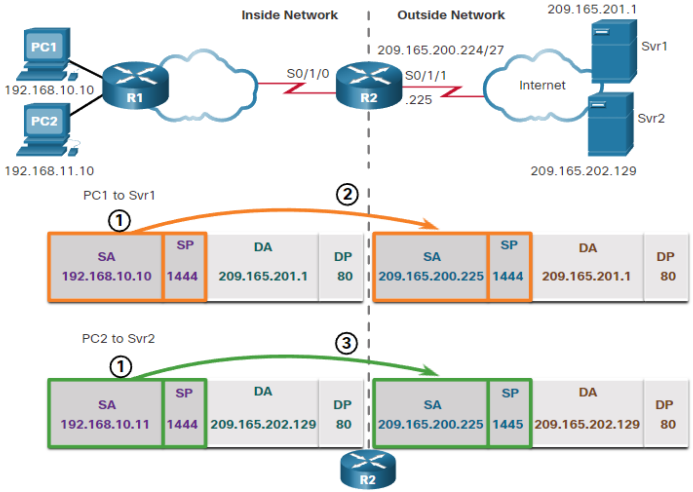
In the example, NAT-POOL2 is bound to an ACL to permit 192.168.0.0/16 to be translated. These hosts can share an IPv4 address from the pool because PAT is enabled with the keyword **overload**.



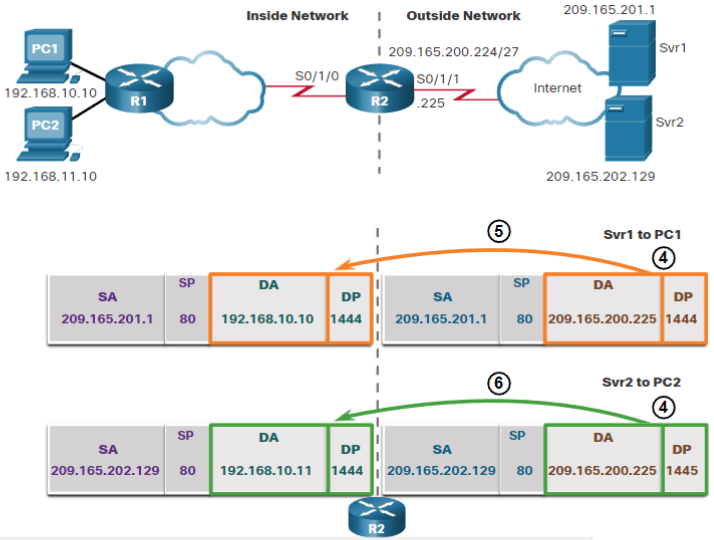

```
R2(config)# ip nat pool NAT-POOL2 209.165.200.226 209.165.200.240 netmask 255.255.255.224
R2(config)# access-list 1 permit 192.168.0.0 0.0.255.255
R2(config)# ip nat inside source list 1 pool NAT-POOL2 overload
R2(config)# interface serial0/1/0
R2(config-if)# ip nat inside
R2(config-if)# interface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

Analyze PAT

In the fgure, the following steps are shown:



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	209.165.201.129:80



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.

- **show ip nat translations**
- **show ip nat statistics**

```
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# 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)
```

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