Configuring Network Address Translation

- Information About Network Address Translation, on page 1
- Configuring NAT, on page 11
- Configuration Examples for Network Address Translation, on page 24
- Troubleshooting Network Address Translation, on page 25
- Feature History for Network Address Translation, on page 25

Information About Network Address Translation

The following sections provide information about Network Address Translation (NAT).

Network Address Translation (NAT)

Network Address Translation (NAT) is designed for IP address conservation. It enables private IP networks that use unregistered IP addresses to connect to the Internet. NAT operates on a device, usually connecting two networks together, and translates the private (not globally unique) addresses in the internal network into global routable addresses, before packets are forwarded onto another network.

NAT can be configured to advertise only one address for the entire network to the outside world. This ability provides additional security by effectively hiding the entire internal network behind that one address. NAT offers the dual functions of security and address conservation and is typically implemented in remote-access environments.

NAT is also used at the enterprise edge to allow internal users access to the Internet and to allow Internet access to internal devices such as mail servers.

Benefits of Configuring NAT

- Resolves the problem of IP depletion.

  NAT allows organizations to resolve the problem of IP address depletion when they have existing networks and need to access the Internet. Sites that do not yet possess Network Information Center (NIC)-registered IP addresses must acquire IP addresses, and if more than 254 clients are present or are planned, the scarcity of Class B addresses becomes a serious issue. NAT addresses these issues by mapping thousands of hidden internal addresses to a range of easy-to-get Class C addresses.

- Provides a layer of security by preventing the client IP address from being exposed to the outside network.

Sites that already have registered IP addresses for clients on an internal network may want to hide those addresses from the Internet so that hackers cannot directly attack clients. With client addresses hidden, a degree of security is established. NAT gives LAN administrators complete freedom to expand Class A addressing, which is drawn from the reserve pool of the Internet Assigned Numbers Authority. The expansion of Class A addresses occurs within the organization without a concern for addressing changes at the LAN or the Internet interface.

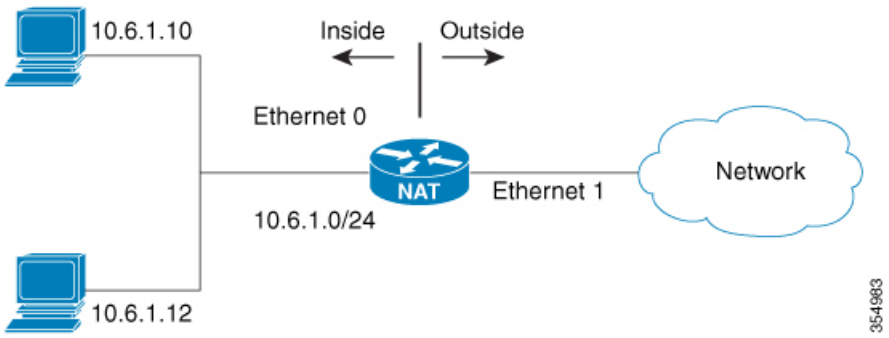
- Cisco software can selectively or dynamically perform NAT. This flexibility allows network administrator to use RFC 1918 addresses or registered addresses.
- NAT is designed for use on a variety of devices for IP address simplification and conservation. In addition, NAT allows the selection of internal hosts that are available for translation.
- A significant advantage of NAT is that it can be configured without requiring any changes to devices other than to those few devices on which NAT will be configured.

How NAT Works

A device that is configured with NAT will have at least one interface to the inside network and one to the outside network. In a typical environment, NAT is configured at the exit device between a stub domain and the backbone. When a packet leaves the domain, NAT translates the locally significant source address into a globally unique address. When a packet enters the domain, NAT translates the globally unique destination address into a local address. Multiple inside networks could be connected to the device and similarly there might exist multiple exit points from the device towards outside networks. If NAT cannot allocate an address because it has run out of addresses, it drops the packet and sends an Internet Control Message Protocol (ICMP) host unreachable packet to the destination.

Translation and forwarding are performed in the hardware switching plane, thereby improving the overall throughput performance. For more details on performance, refer the section on Performance and Scale Numbers for NAT.

Figure 1: NAT



Uses of NAT

NAT can be used for the following scenarios:

- To connect to the Internet when only a few of your hosts have globally unique IP address.

  NAT is configured on a device at the border of a stub domain (referred to as the inside network) and a public network such as the Internet (referred to as the outside network). NAT translates internal local

addresses to globally unique IP addresses before sending packets to the outside network. As a solution to the connectivity problem, NAT is practical only when relatively few hosts in a stub domain communicate outside of the domain at the same time. When this is the case, only a small subset of the IP addresses in the domain must be translated into globally unique IP addresses when outside communication is necessary, and these addresses can be reused

- Renumbering:

  Instead of changing the internal addresses, which can be a considerable amount of work, you can translate them by using NAT.

NAT Inside and Outside Addresses

The term *inside* in a NAT context refers to networks owned by an organization that must be translated. When NAT is configured, hosts within this network will have addresses in one space (known as the local address space) that will appear to those outside the network as being in another space (known as the global address space).

Similarly, the term outside refers to those networks to which the stub network connects, and which are generally not under the control of an organization. Hosts in outside networks can also be subject to translation, and can thus have local and global addresses.

NAT uses the following definitions:

- Inside local address—an IP address that is assigned to a host on the inside network. The address is probably not a routable IP address assigned by NIC or service provider.
- Inside global address—a global routable IP address (assigned by the NIC or service provider) that represents one or more inside local IP addresses to the outside world.
- Outside local address—the IP address of an outside host as it appears to the inside network. Not necessarily a routable IP address, it is allocated from the address space that is routable on the inside.
- Outside global address—the IP address assigned to a host on the outside network by the owner of the host. The address is allocated from a globally routable address or network space.
- Inside Source Address Translation—translates an inside local address to inside global address.
- Outside Source Address Translation—translates the outside global address to outside local address.
- Static Port Translation—translates the IP address and port number of an inside/outside local address to the IP address and port number of the corresponding inside/outside global address.
- Static Translation of a given subnet—translates a specified range of subnets of an inside/outside local address to the corresponding inside/outside global address.
- Half Entry—represents a mapping between the local and global address/ports and is maintained in the translation database of NAT module. A half entry may be created statically or dynamically based on the configured NAT rule.
- Full Entry/Flow entry—represents a unique flow corresponding to a given session. In addition to the local to global mapping, it also maintains the destination information which fully qualifies the given flow. A Full entry is always created dynamically and maintained in the translation database of NAT module.

VRF Aware NAT

NAT is typically configured to operate across the default or global routing domain. As per this feature, the inside and outside NAT domains are associated with the default VRF space and the translations are effected accordingly. However, there are certain scenarios where NAT is required to operate in a VRF setting. One common scenario involves enabling shared service access for private networks that have overlapping address space. In such cases, the given private networks can be placed in different VRFs and global service access can be achieved by configuring VRF aware NAT rules that map overlapping private address to unique global address. VRF awareness enables NAT to carry out address and port translation by taking the VRF of the private networks into consideration.

VRF-aware NAT supports only VRF to Global translation of IP addresses. VRF to Global translation is between a NAT inside interface that is associated with a specific VRF and a NAT outside interface that is associated with the global VRF. Intra-VRF NAT translation (which involves the NAT-inside and NAT-outside interfaces of the same specific VRF) and Inter-VRF NAT translation (which involves NAT-inside and NAT-outside interfaces that are associated with different VRFs) are not formally supported. NAT behavior is undefined in such unsupported scenarios. We recommend that you deploy only the VRF to Global NAT translation in your network.

Types of NAT

You can configure NAT such that it will advertise only a single address for your entire network to the outside world. Doing this effectively hides the internal network from the world, giving you some additional security.

The types of NAT include:

- Static address translation (static NAT)—Allows one-to-one mapping between local and global addresses.
- Dynamic address translation (dynamic NAT)—Maps unregistered IP addresses to registered IP addresses from a pool of registered IP addresses.
- Overloading / PAT—Maps multiple unregistered IP addresses to a single registered IP address (many to one) using different Layer 4 ports. This method is also known as Port Address Translation (PAT). By using overloading, thousands of users can be connected to the Internet by using only one real global IP address.

Using NAT to Route Packets to the Outside Network (Inside Source Address Translation)

You can translate unregistered IP addresses into globally unique IP addresses when communicating outside your network.

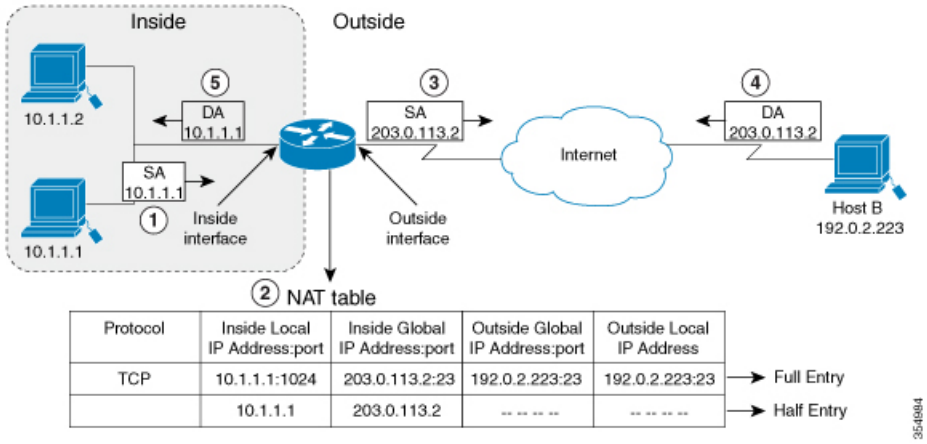
You can configure static or dynamic inside source address translation as follows:

- Static translation establishes a one-to-one mapping between the inside local address and an inside global address. Static translation is useful when a host on the inside must be accessible by a fixed address from the outside. Static translation can be enabled by configuring a static NAT rule as explained in the Configuring Static Translation of Inside Source Addresses, on page 11 section.
- Dynamic translation establishes a mapping between an inside local address and a pool of global addresses dynamically. Dynamic translation can be enabled by configuring a dynamic NAT rule and the mapping is established based on the result of the evaluation of the configured rule at run-time. You can employ

an Access Control List (ACL), both Standarad and Extended ACLs, to specify the inside local address. The inside global address can be specified through an address pool or an interface. Dynamic translation is enabled by configuring a dynamic rule as explained in the Configuring Dynamic Translation of Inside Source Addresses, on page 13 section.

The following figure illustrates a device that is translating a source address inside a network to a source address outside the network.

Figure 2: NAT Inside Source Translation



The following process describes the inside source address translation, as shown in the figure above:

1. The user at host 10.1.1.1 opens a connection to Host B in the outside network.
2. NAT module intercepts the corresponding packet and attempts to translate the packet.

   The following scenarios are possible based on the presence or absence of a matching NAT rule:

   - If a matching static translation rule exists, the packet gets translated to the corresponding inside global address. Otherwise, the packet is matched against the dynamic translation rule and in the event of a successful match, it gets translated to the corresponding inside global address. The NAT module inserts a fully qualified flow entry corresponding to the translated packet, into its translation database. This facilitates fast translation and forwarding of the packets corresponding to this flow, in either direction.
   - The packet gets forwarded without any address translation in the absence of a successful rule match.
   - The packet gets dropped in the event of failure to obtain a valid inside global address even-though we have a successful rule match.

Note If an ACL is employed for dynamic translation, NAT evaluates the ACL and ensures that only the packets that are permitted by the given ACL are considered for translation.

3. The device replaces the inside local source address of host 10.1.1.1 with the inside global address of the translation, 203.0.113.2, (only the packet-relevant checksums get updated and all other fields in the packet remain unchanged) and forwards the packet.

4. The NAT module inserts a fully qualified flow entry corresponding to the translated packet flow, into its translation database. This facilitates fast translation and forwarding of packets corresponding to the flow in either direction.
5. Host B receives the packet and responds to host 10.1.1.1 by using the inside global IP destination address (DA) 203.0.113.2
6. The response packet from host B would be destined to the inside global address and the NAT module intercepts this packet and translates it back to the corresponding inside local address with the help of the flow entry that has been setup in the translation database.

Host 10.1.1.1 receives the packet and continues the conversation. The device performs Steps 2 to 5 for each packet that it receives.

Outside Source Address Translation

You can translate the source address of the IP packets that travel from outside of the network to inside the network. This type of translation is usually employed in conjunction with inside source address translation to interconnect overlapping networks.

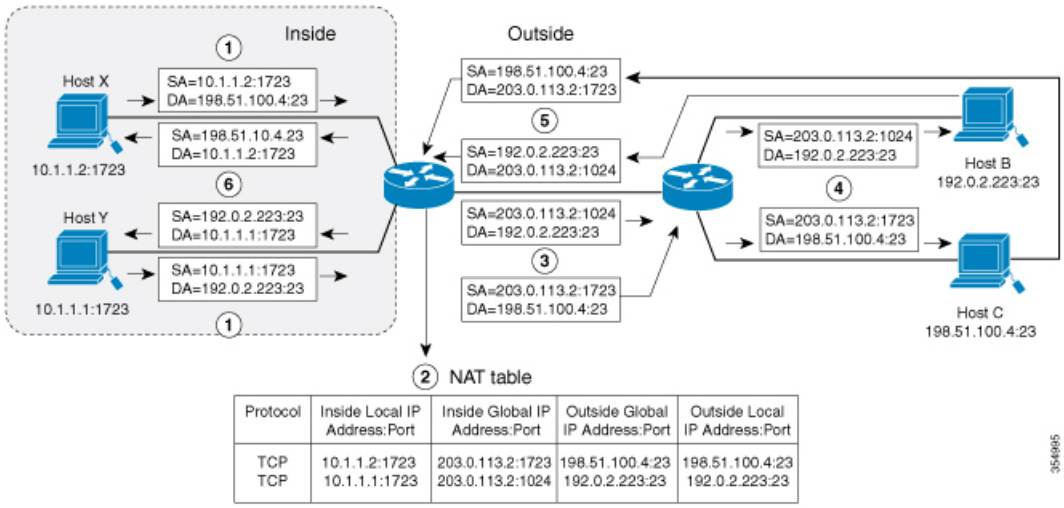
This process is explained in the section on Configuring Translation of Overlapping Networks, on page 20

Port Address Translation (PAT)

You can conserve addresses in the inside global address pool by allowing a device to use one global address for many local addresses and this type of NAT configuration is called overloading or port address translation. When overloading is configured, the device maintains enough information from higher-level protocols (for example, TCP or UDP port numbers) to translate the global address back to the correct local address. When multiple local addresses map to one global address, the TCP or UDP port numbers of each inside host distinguish between the local addresses.

The figure below illustrates a NAT operation when an inside global address represents multiple inside local addresses. The TCP port numbers act as differentiators.

Figure 3: PAT / NAT Overloading Inside Global Addresses



The device performs the following process in the overloading of inside global addresses, as shown in the figure above. Both Host B and Host C believe that they are communicating with a single host at address 203.0.113.2. Whereas, they are actually communicating with different hosts; the port number is the differentiator. In fact, many inside hosts can share the inside global IP address by using many port numbers.

1. The user at Host Y opens a connection to Host B and the user at Host X opens a connection to Host C.
2. NAT module intercepts the corresponding packets and attempts to translate the packets.

   Based on the presence or absence of a matching NAT rule the following scenarios are possible:

   - If a matching static translation rule exists, then it takes precedence and the packets are translated to the corresponding global address. Otherwise, the packets are matched against dynamic translation rule and in the event of a successful match, they are translated to the corresponding global address. NAT module inserts a fully qualified flow entry corresponding to the translated packets, into its translation database, to facilitate fast translation and forwarding of the packets corresponding to this flow, in either direction.
   - The packets get forwarded without any address translation in the absence of a successful rule match.
   - The packets get dropped in the event of failure to obtain a valid inside global address even though we have a successful rule match.
   - As this is a PAT configuration, transport ports help translate multiple flows to a single global address. (In addition to source address, the source port is also subjected to translation and the associated flow entry maintains the corresponding translation mappings.)

3. The device replaces inside local source address/port 10.1.1.1/1723 and 10.1.1.2/1723 with the corresponding selected global address/port 203.0.113.2/1024 and 203.0.113.2/1723 respectively and forwards the packets.
4. Host B receives the packet and responds to Host Y by using the inside global IP address 203.0.113.2, on port 1024. Host C receives the packet and responds to Host X using the inside global IP adress 203.0.113.2, on port 1723.
5. When the device receives the packets with the inside global IP address, it performs a NAT table lookup; the inside global address and port, and the outside address and port as keys; translates the addresses to the inside local addresses 10.1.1.1:1723 / 10.1.1.2:1723 and forwards the packets to Host Y and Host X respectively.

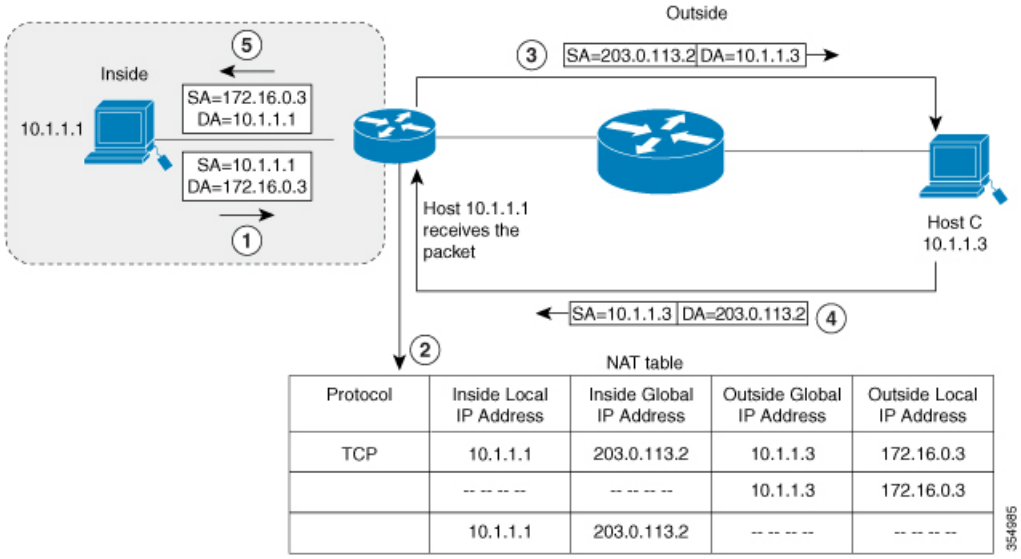
Host Y and Host X receive the packet and continue the conversation. The device performs Steps 2 to 5 for each packet it receives.

Overlapping Networks

Use NAT to translate IP addresses if the IP addresses that you use are neither legal nor officially assigned. Overlapping networks result when you assign an IP address to a device on your network that is already legally owned and assigned to a different device on the Internet or outside the network.

The following figure depicts overlapping networks: the inside network and outside network both have the same local IP addresses (10.1.1.x). You need network connectivity between such overlapping address spaces with one NAT device to translate the address of a remote peer (10.1.1.3) to a different address from the perspective of the inside.

Figure 4: NAT Translating Overlapping Addresses



Notice that the inside local address (10.1.1.1) and the outside global address (10.1.1.3) are in the same subnet. To translate the overlapping address, first, the inside source address translation happens with the inside local address getting translated to 203.0.113.2 and a half entry is created in the NAT table. On the Receiving side, the outside source address is translated to 172.16.0.3 and another half entry is created. The NAT table is then updated with a full entry of the complete translation.

The following steps describe how a device translates overlapping addresses:

1. Host 10.1.1.1 opens a connection to 172.16.0.3.
2. The NAT module sets up the translation mapping of the inside local and global addresses to each other and the outside global and local addresses to each other
3. The Source Address (SA) is replaced with inside global address and the Destination Address (DA) is replaced with outside global address.
4. Host C receives the packet and continues the conversation.
5. The device does a NAT table lookup, replaces the DA with inside local address, and replaces the SA with outside local address.
6. Host 10.1.1.1 receives the packet and the conversation continues using this translation process.

Limitations of NAT

- There are certain NAT operations that are currently not supported in the hardware data plane. The following are such operations that are carried out in the relatively slower Software data plane:
  - Translation of Internet Control Message Protocol (ICMP) packets.
  - Translation of packets that require application layer gateway (ALG) processing.
  - Packets that require both inside and outside translation.

Note This does not apply to the Cisco Catalyst 9500 Series Switches.

- The maximum number of sessions that can be translated and forwarded in the hardware in an ideal setting is limited to 7000 for the Cisco Catalyst 9500 Series Switches and 7750 for the Cisco Catalyst 9500 High Performance Series Switches. For the Cisco Catalyst 9500 Series Switches, the maximum number of sessions that can be translated is based on SDM template configured. Additional flows that require translation are handled in the software data plane at a reduced throughput.

Note Each translation consumes two entries in TCAM.

- For NAT traffic, the CPU Queue bandwidth limitation is 2000 packets. Packets that exceed this limit will be dropped.
- A configured NAT rule might fail to get programmed into the hardware owing to resource constraint. This could result in packets that correspond to the given rule to get forwarded without translation.

Note This does not apply to the Cisco Catalyst 9500 Series Switches.

- ALG support is currently limited to FTP, TFTP and ICMP protocols. Also, although TCP SYN, TCP FIN, and TCP RST are not part of ALG traffic, they are processed as part of ALG traffic.
- Dynamically created NAT flows age out after a period of inactivity. For the Cisco Catalyst 9500 Series Switches, the number of NAT flows whose activity can be tracked depends on the SDM template configured. For example, the number of NAT flows whose activity can be tracked is limited to 14000 when NAT template is configured. As a result, it is possible that certain active NAT flows get prematurely removed in cases where the total number of NAT flows exceeds the maximum limit. Also, attributes such as *used time* and *remaining time* associated with the NAT flows might report incorrect values in such cases.
- Policy Based Routing (PBR) and NAT are not supported on the same interface. PBR and NAT work together only if they are configured on different interfaces.
- Port Channel is not supported in NAT configuration.
- NAT does not support translation of fragmented packets.
- Bidirectional Forwarding Detection (BFD) sessions may fail if they are configured to operate using the same address that is used for dynamic NAT. To avoid a conflict that arises when both BFD and Dynamic NAT are configured on the device, use an address that does not overlap with NAT. If you must configure BFD and dynamic NAT overloading on the same interface, deploy a pool-based dynamic NAT overload configuration. Ensure that you do not use the chosen NAT pool address for BFD even in this scenario.
- Equal-cost multi-path routing (ECMP) is not supported with NAT.
- NAT configuration must be done without using route-maps, as route-mapped NAT is not supported.
- Explicit deny access control entry (ACE) in NAT ACL is not supported. Only explicit permit ACE is supported.

Performance and Scale Numbers for NAT

NAT module is capable of performing translation and forwarding in the hardware at line-rate, by programming the relevant hardware tables with the forwarding and rewrite information. You can configure a NAT-focused resource allocation scheme to obtain increased NAT throughput.

Configure SDM template NAT to achieve better performance and scale number. Refer Configuring Switch Database Management (SDM) Template, on page 23

The maximum number of TCAM flows that are available in the hardware is 14000 for the Cisco Catalyst 9500 Series Switch and 15500 for the Cisco Catalyst 9500 High Performance Series Switches.

Note Using Address Only Translation optimizes the handling of flows and enhances the scale of the NAT feature.

Address Only Translation

Address only Translation (AOT) functionality can be employed in situations that require only the address fields to be translated and not the transport ports. In such settings, enabling AOT functionality significantly increases the number of flows that can be translated and forwarded in the hardware at line-rate. This improvement is brought about by optimizing the usage of various hardware resources associated with translation and forwarding. A typical NAT focused resource allocation scheme sets aside 14000 (Cisco Catalyst 9500 Series Switch) and 15500 (Cisco Catalyst 9500 High Performance Series Switches) TCAM entries for performing hardware translation. This places a strict upper limit on the number of flows that can be translated and forwarded at line-rate. Under AOT scheme, the usage of TCAM resource is highly optimized thereby enabling the accommodation of more number of flows in the TCAM tables and this provides a significant improvement in the hardware translation and forwarding scale. AOT can be very effective in situations where majority of the flows are destined to a single or a small set of destinations. Under such favourable conditions, AOT can potentially enable line-rate translation and forwarding of all the flows originating from the given end-point(s). AOT functionality is disabled by default. It can be enabled using the **no ip nat create flow-entries** command. The existing dynamic flow can be cleared using the **clear ip nat translation** command. The AOT feature can be disabled using the **ip nat create flow-entries** command.

Restrictions for Address Only Translation

- AOT feature is expected to function correctly only in translation scenarios corresponding to simple inside static and inside dynamic rules. The simple static rule must be of the type **ip nat inside source static** *local-ip global-ip*, and the dynamic rule must be of the type **ip nat inside source list** *access-list* **pool** *name*.
- When AOT is enabled, the **show ip nat translations** command will not give visibility into all the NAT flows being translated and forwarded.

Using Application-Level Gateways with NAT

NAT performs translation services on any TCP/UDP traffic that does not carry source and destination IP addresses in the application data stream. Protocols that do not carry the source and destination IP addresses include HTTP, TFTP, telnet, archie, finger, Network Time Protocol (NTP), Network File System (NFS), remote login (rlogin), remote shell (rsh) protocol, and remote copy (rcp).

NAT Application-Level Gateway (ALG) enables certain applications that carry address/port information in their payloads to function correctly across NAT domains. In addition to the usual translation of address/ports in the packet headers, ALGs take care of translating the address/ports present in the payload and setting up temporary mappings.

Best Practices for NAT Configuration

- In cases where both static and dynamic rules are configured, ensure that the local addresses specified in the rules do not overlap. If such an overlap is possible, then the ACL associated with the dynamic rule should exclude the corresponding addresses used by the static rule. Similarly, there must not be any overlap between the global addresses as this could lead to undesired behavior.
- VRF to Global translation functionality considers the NAT outside interface to be associated with default or global VRF. Therefore, placing the NAT outside interface in a non-default VRF is not recommended while performing VRF aware NAT.
- Do not employ loose filtering such as **permit ip any any** in an ACL associated with NAT rule as this could result in unwanted packets being translated.
- Do not share an address pool across multiple NAT rules.
- Do not define the same inside global address in Static NAT and Dynamic Pool. This action can lead to undesirable results.
- Exercise caution while modifying the default timeout values associated with NAT. Small timeout values could result in high CPU usage.
- Exercise caution while manually clearing the translation entries as this could result in the disruption of application sessions.
- Follow these steps before you make NAT configuration changes during active translations.
    - Stop the ingress and egress of traffic matching the given configuration. This may require applying an appropriate ACL filter or shutting down the given interfaces.
    - Clear any existing translation entries that correspond to the given configuration.
    - Make the desired configuration change and re-enable the stopped traffic.

Configuring NAT

The tasks described in this section will help you configure NAT. Based on the desired configuration, you may need to configure more than one task.

Configuring Static Translation of Inside Source Addresses

Configure static translation of inside source address to allow one-to-one mapping between an inside local address and an inside global address. Static translation is useful when a host on the inside must be accessible by a fixed address from the outside.

Procedure

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.

Step 3	Use any of the following commands depending on the requirement:
	• **ip nat inside source static** *local-ip global-ip*
	`Switch(config)# ip nat inside source static 10.10.10.1 172.16.131.1`
	• **ip nat inside source static** *protocol local-ip port global-ip port*
	`Switch(config)# ip nat inside source static tcp 10.10.10.1 1234 172.16.131.1 5467`
	• **ip nat inside source static network** *local-ip global-ip* {**prefix_len** *len* | **subnet** *subnet-mask*}
	`Switch(config)# ip nat inside source static network 10.10.10.1 172.16.131.1 prefix_len 24`
	• **ip nat inside source static** *local-ip global-ip* **vrf** *vrf-name*
	`Switch(config)# ip nat inside source static 10.10.10.1 172.16.131.1 vrf vrf1`
		• Establishes static translation between an inside local address and an inside global address.
		• Establishes a static port translation between an inside local address and an inside global address.
		• Allows a static translation mapping for an entire subnet without the need for specifying multiple individual translation rules. You can specify the translation mapping for the desired subnet. The actual translation is performed by translating the network portion of the address with the host the portion remaining unchanged.
		• Makes the static translation VRF aware and associates the given rule with the specified VRF.

Step 4	**interface** *type number* **Example:** `Switch(config)# interface ethernet 1`	Specifies an interface and enters interface configuration mode.
Step 5	**ip address** *ip-address mask* **[secondary]** **Example:** `Switch(config-if)# ip address 10.114.11.39 255.255.255.0`	Sets a primary IP address for an interface.
Step 6	**ip nat inside** **Example:** `Switch(config-if)# ip nat inside`	Connects the interface to the inside network, which is subject to NAT.

	Command or Action	Purpose
Step 7	**exit** **Example:** `Switch(config-if)# exit`	Exits interface configuration mode and returns to global configuration mode.
Step 8	**interface** *type number* **Example:** `Switch(config)# interface gigabitethernet 0/0/0`	Specifies a different interface and enters interface configuration mode.
Step 9	**ip address** *ip-address mask* **[secondary]** **Example:** `Switch(config-if)# ip address 172.31.232.182 255.255.255.240`	Sets a primary IP address for an interface.
Step 10	**ip nat outside** **Example:** `Switch(config-if)# ip nat outside`	Connects the interface to the outside network.
Step 11	**end** **Example:** `Switch(config-if)# end`	Exits interface configuration mode and returns to privileged EXEC mode.

Configuring Dynamic Translation of Inside Source Addresses

Dynamic translation establishes a mapping between an inside local address and a pool of global addresses dynamically. Dynamic translation can be enabled by configuring a dynamic NAT rule and the mapping is established based on the result of the evaluation of the configured rule at run-time. You can employ an ACL to specify the inside local address and the inside global address can be specified through an address pool or an interface.

Dynamic translation is useful when multiple users on a private network need to access the Internet. The dynamically configured pool IP address may be used as needed and is released for use by other users when access to the internet is no longer required.

Procedure

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.

	Command or Action	Purpose
Step 3	**ip nat pool** *name start-ip end-ip* **netmask** *netmask* | **prefix-length** *prefix-length* **Example:** `Switch(config)# ip nat pool net-208 172.16.233.208 172.16.233.223 prefix-length 28`	Defines a pool of global addresses to be allocated as needed.
Step 4	**access-list** *access-list-number* **permit** *source [source-wildcard]* **Example:** `Switch(config)# access-list 1 permit 192.168.34.0 0.0.0.255`	Defines a standard access list permitting those addresses that are to be translated.
Step 5	**ip nat inside source list** *access-list-number* **pool** *name* **vrf** *vrf-name* **Example:** `Switch(config)# ip nat inside source list 1 pool net-208`	Establishes dynamic source translation, specifying the access list defined in Step 4. Using the **vrf** keyword makes the dynamic translation VRF aware and associates the given rule with the specified VRF.
Step 6	**interface** *type number* **Example:** `Switch(config)# interface ethernet 1`	Specifies an interface and enters interface configuration mode.
Step 7	**ip address** *ip-address mask* **Example:** `Switch(config-if)# ip address 10.114.11.39 255.255.255.0`	Sets a primary IP address for the interface.
Step 8	**ip nat inside** **Example:** `Switch(config-if)# ip nat inside`	Connects the interface to the inside network, which is subject to NAT.
Step 9	**exit** **Example:** `Switch(config-if)#exit`	Exits the interface configuration mode and returns to global configuration mode.
Step 10	**interface** *type number* **Example:** `Switch(config)# interface ethernet 0`	Specifies an interface and enters interface configuration mode.
Step 11	**ip address** *ip-address mask* **Example:** `Switch(config-if)# ip address 172.16.232.182 255.255.255.240`	Sets a primary IP address for the interface.

	Command or Action	Purpose
Step 12	**ip nat outside** **Example:** `Switch(config-if)# ip nat outside`	Connects the interface to the outside network.
Step 13	**end** **Example:** `Switch(config-if)# end`	Exits interface configuration mode and returns to privileged EXEC mode.

Configuring Port Address Translation

Configuring PAT by Overloading of Global Addresses

NAT module supports dynamic PAT configurations through address pools and interface, as described in the following tasks.

Perform the following task to allow your internal users access to the Internet and conserve addresses in the inside global address pool using overloading of global addresses.

Procedure

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 3	**ip nat pool** *name start-ip end-ip* **netmask** *netmask* | **prefix-length** *prefix-length* **Example:** `Switch(config)# ip nat pool net-208 192.168.202.129 192.168.202.158 netmask 255.255.255.224`	Defines a pool of global addresses to be allocated as needed.
Step 4	**access-list** *access-list-number* **permit** *source [source-wildcard]* **Example:** `Switch(config)# access-list 1 permit 192.168.201.30 0.0.0.255`	Defines a standard access list permitting those addresses that are to be translated. The access list must permit only those addresses that are to be translated. (Remember that there is an implicit “deny all” at the end of each access list.) Use of an access list that is too permissive can lead to unpredictable results.

	Command or Action	Purpose
Step 5	**ip nat inside source list** *access-list-number* **pool** *name* [**vrf** *vrf-name*] **overload** **Example:** `Switch(config)# ip nat inside source list 1 pool net-208 overload`	Establishes dynamic source translation with overloading, specifying the access list defined in Step 4. Using the **vrf** keyword makes the dynamic translation VRF aware and associates the given rule with the specified VRF.
Step 6	**interface** *type number* **Example:** `Switch(config)# interface ethernet 1`	Specifies an interface and enters interface configuration mode.
Step 7	**ip address** *ip-address mask* **[secondary]** **Example:** `Switch(config-if)# ip address 192.168.201.1 255.255.255.240`	Sets a primary IP address for an interface.
Step 8	**ip nat inside** **Example:** `Switch(config-if)# ip nat inside`	Connects the interface to the inside network, which is subject to NAT.
Step 9	**exit** **Example:** `Switch(config-if)# exit`	Exits interface configuration mode and returns to global configuration mode.
Step 10	**interface** *type number* **Example:** `Switch(config)# interface ethernet 0`	Specifies a different interface and enters interface configuration mode.
Step 11	**ip address** *ip-address mask* **[secondary]** **Example:** `Switch(config-if)#  ip address 192.168.201.29 255.255.255.240`	Sets a primary IP address for an interface.
Step 12	**ip nat outside** **Example:** `Switch(config-if)# ip nat outside`	Connects the interface to the outside network.
Step 13	**end** **Example:** `Switch(config-if)# end`	Exits interface configuration mode and returns to privileged EXEC mode.

Configuring PAT by Overloading an Interface

Perform the following task to allow your internal users access to the Internet and conserve addresses in the inside global address pool by overloading an interface.

Procedure

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 3	**access-list** *access-list-number* **permit** *source [source-wildcard]* **Example:** `Switch(config)# access-list 1 permit 192.168.201.30 0.0.0.255`	Defines a standard access list permitting those addresses that are to be translated. The access list must permit only those addresses that are to be translated. (Note that there is an implicit "deny all" at the end of each access list.) Use of an access list that is too permissive can lead to unpredictable results.
Step 4	**ip nat inside source list** *access-list-number* **interface** *name* **overload** **Example:** `Switch(config)# ip nat inside source list 1 interface gigabitethernet0/0/2 overload`	Establishes dynamic source translation with overloading, specifying the access list defined in Step 3. **Note** For overloading, you can choose any Layer 3 interface that has a valid IP address and is in operational state.
Step 5	**interface** *type number* **Example:** `Switch(config)# interface gigabitethernet0/0/1`	Specifies an interface and enters interface configuration mode.
Step 6	**ip address** *ip-address mask* **[secondary]** **Example:** `Switch(config-if)# ip address 192.168.201.1 255.255.255.240`	Sets a primary IP address for an interface.
Step 7	**ip nat inside** **Example:** `Switch(config-if)# ip nat inside`	Connects the interface to the inside network, which is subject to NAT.
Step 8	**exit** **Example:** `Switch(config-if)# exit`	Exits interface configuration mode and returns to global configuration mode.
Step 9	**interface** *type number* **Example:**	Specifies a different interface and enters interface configuration mode.

	Command or Action	Purpose
	`Switch(config)# interface gigabitethernet0/0/2`	
Step 10	**ip address** *ip-address mask* **[secondary]** **Example:** `Switch(config-if)#  ip address 192.168.201.29 255.255.255.240`	Sets a primary IP address for an interface.
Step 11	**ip nat outside** **Example:** `Switch(config-if)# ip nat outside`	Connects the interface to the outside network.
Step 12	**end** **Example:** `Switch(config-if)# end`	Exits interface configuration mode and returns to privileged EXEC mode.

Configuring NAT of External IP Addresses Only

By default, NAT translates the addresses embedded in the packet pay-load as explained in Using Application-Level Gateways with NAT, on page 10 section. There might be situations where the translation of the embedded address is not desirable and in such cases, NAT can be configured to translate the external IP address only.

Procedure

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**ip nat inside source** {**list** {*access-list-number* | *access-list-name*} **pool** *pool-name* [**overload**] | **static network** *local-ip global-ip* [**no-payload**]} **Example:** `Device(config)# ip nat inside source static network 10.1.1.1 192.168.251.0/24 no-payload`	Disables the network packet translation on the inside host device.

	Command or Action	Purpose
Step 4	**ip nat inside source** {**list** {*access-list-number* | *access-list-name*} **pool** *pool-name* [**overload**] | **static** {**tcp** | **udp**} *local-ip local-port global-ip global-port* [**no-payload**]} **Example:** `Device(config)# ip nat inside source static tcp 10.1.1.1 2000 192.168.1.1 2000 no-payload`	Disables port packet translation on the inside host device.
Step 5	**ip nat inside source** {**list** {*access-list-number* | *access-list-name*} **pool** *pool-name* [**overload**] | **static** [**network**] *local-network-mask global-network-mask* [**no-payload**]} **Example:** `Device(config)# ip nat inside source static 10.1.1.1 192.168.1.1 no-payload`	Disables packet translation on the inside host device.
Step 6	**ip nat outside source** {**list** {*access-list-number* | *access-list-name*} **pool** *pool-name* | **static** *local-ip global-ip* [**no-payload**]} **Example:** `Device(config)# ip nat outside source static 10.1.1.1 192.168.1.1 no-payload`	Disables packet translation on the outside host device.
Step 7	**ip nat outside source** {**list** {*access-list-number* | *access-list-name*} **pool** *pool-name* | **static** {**tcp** | **udp**} *local-ip local-port global-ip global-port* [**no-payload**]} **Example:** `Device(config)# ip nat outside source static tcp 10.1.1.1 20000 192.168.1.1 20000 no-payload`	Disables port packet translation on the outside host device.
Step 8	**ip nat outside source** {**list** {*access-list-number* | *access-list-name*} **pool** *pool-name* | **static** [**network**] *local-network-mask global-network-mask* [**no-payload**]} **Example:** `Device(config)# ip nat outside source static network 10.1.1.1 192.168.251.0/24 no-payload`	Disables network packet translation on the outside host device.
Step 9	**exit** **Example:** `Device(config)# exit`	Exits global configuration mode and returns to privileged EXEC mode.

	Command or Action	Purpose
Step 10	**show ip nat translations** [**verbose**] **Example:** `Device# show ip nat translations`	Displays active NAT.

Configuring Translation of Overlapping Networks

Configure static translation of overlapping networks if your IP addresses in the stub network are legitimate IP addresses belonging to another network and you want to communicate with those hosts or routers using static translation.

Note For a successful NAT outside translation, the device should be configured with a route for the outside local address. You can configure the route either manually or using the **add-route** option associated with **ip nat outside source** {**static** | **list**} command. We recommend that you use the **add-route** option to enable automatic creation of the route.

Procedure

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	
Step 3	**ip nat inside source static** *local-ip global-ip* **Example:** `Switch(config)# ip nat inside source static 10.1.1.1 203.0.113.2`	Establishes static translation between an inside local address and an inside global address.
Step 4	**ip nat outside source static** *local-ip global-ip* **Example:** `Switch(config)# ip nat outside source static 172.16.0.3 10.1.1.3`	Establishes static translation between an outside local address and an outside global address.
Step 5	**interface** *type number* **Example:** `Switch(config)# interface ethernet 1`	Specifies an interface and enters interface configuration mode.
Step 6	**ip address** *ip-address mask* **Example:**	Sets a primary IP address for an interface.

	Command or Action	Purpose
	`Switch(config-if)# ip address 10.114.11.39 255.255.255.0`	
Step 7	**ip nat inside** **Example:** `Switch(config-if)# ip nat inside`	Marks the interface as connected to the inside.
Step 8	**exit** **Example:** `Switch(config-if)# exit`	Exits interface configuration mode and returns to global configuration mode.
Step 9	**interface** *type number* **Example:** `Switch(config)# interface ethernet 0`	Specifies a different interface and enters interface configuration mode.
Step 10	**ip address** *ip-address mask* **Example:** `Switch(config-if)#  ip address 172.16.232.182 255.255.255.240`	Sets a primary IP address for an interface.
Step 11	**ip nat outside** **Example:** `Switch(config-if)# ip nat outside`	Marks the interface as connected to the outside.
Step 12	**end** **Example:** `Switch(config-if)# end`	Exits interface configuration mode and returns to privileged EXEC mode.

Configuring Address Translation Timeouts

You can configure address translation timeouts based on your NAT configuration.

By default, dynamically created translation entries time-out after a period of inactivity to enable the efficient use of various resources. You can change the default values on timeouts, if necessary. The following are the default time-out configurations associated with major translation types :

- Established TCP sessions: 24 hours
- UDP flow: 5 minutes
- ICMP flow: 1 minute

The default timeout values are adequate to address the timeout requirements in most of the deployment scenarios. However, these values can be adjusted/fine-tuned as appropriate. It is recommended not to configure very small timeout values (less than 60 seconds) as it could result in high CPU usage. Refer the Best Practices for NAT Configuration, on page 11 section for more information.

Based on your configuration, you can change the timeouts described in this section.

- If you need to quickly free your global IP address for a dynamic configuration, configure a shorter timeout than the default timeout, by using the **ip nat translation timeout** command. However, the configured timeout should be longer than the other timeouts configured using commands specified in the following steps.
- If a TCP session is not properly closed by a finish (FIN) packet from both sides or during a reset, change the default TCP timeout by using the **ip nat translation tcp-timeout** command.

Procedure

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 3	**ip nat translation** *seconds* **Example:** `Switch(config)# ip nat translation 300`	(Optional) Changes the amount of time after which NAT translations time out. The default timeout is 24 hours, and it applies to the aging time for half-entries.
Step 4	**ip nat translation udp-timeout** *seconds* **Example:** `Switch(config)# ip nat translation udp-timeout 300`	(Optional) Changes the UDP timeout value.
Step 5	**ip nat translation tcp-timeout** *seconds* **Example:** `Switch(config)# ip nat translation tcp-timeout 2500`	(Optional) Changes the TCP timeout value. The default is 24 hours.
Step 6	**ip nat translation finrst-timeout** *seconds* **Example:** `Switch(config)# ip nat translation finrst-timeout 45`	(Optional) Changes the finish and reset timeout value. finrst-timeout—The aging time after a TCP session receives both finish-in (FIN-IN) and finish-out (FIN-OUT) requests or after the reset of a TCP session.
Step 7	**ip nat translation icmp-timeout** *seconds* **Example:** `Switch(config)# ip nat translation icmp-timeout 45`	(Optional) Changes the ICMP timeout value.
Step 8	**ip nat translation syn-timeout** *seconds* **Example:**	(Optional) Changes the synchronous (SYN) timeout value.

	Command or Action	Purpose
	`Switch(config)# ip nat translation syn-timeout 45`	The synchronous timeout or the aging time is used only when a SYN request is received on a TCP session. When a synchronous acknowledgment (SYNACK) request is received, the timeout changes to TCP timeout.
Step 9	**end** **Example:** `Switch(config-if)# end`	Exits interface configuration mode and returns to privileged EXEC mode.

Configuring Switch Database Management (SDM) Template

Use SDM templates to configure system resources to optimize support for NAT.

After you set the template and the system reboots, you can use the **show sdm prefer** privileged EXEC command to verify the new template configuration. If you enter the **show sdm prefer** command before you enter the **reload** privileged EXEC command, the **show sdm prefer** command shows the template currently in use and the template that will become active after a reload.

Follow these steps to set the SDM template to maximize NAT usage:

Procedure

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 2	**sdm prefer nat** **Example:** `Switch(config)# sdm prefer nat`	Specifies the SDM template to be used on the switch. Starting from Cisco IOS XE Gibraltar 16.12.1 , this template is available under the network-advantage license. On all earlier releases, it is available under the DNA Advantage license.
Step 3	**end** **Example:** `Switch(config)# end`	Returns to the privileged EXEC mode.
Step 4	**write memory** **Example:** `Switch# write memory`	Save the current configuration before reload.
Step 5	**reload** **Example:**	Reloads the operating system.

	Command or Action	Purpose
	`Switch# reload`	

Configuration Examples for Network Address Translation

Example: Configuring Static Translation of Inside Source Addresses

The following example shows how inside hosts addressed from the 10.114.11.0 network are translated to the globally unique 172.31.233.208/28 network. Further, packets from outside hosts that are addressed from the 10.114.11.0 network (the true 10.114.11.0 network) are translated to appear from the 10.0.1.0/24 network.

```
ip nat pool net-208 172.31.233.208 172.31.233.223 prefix-length 28
ip nat pool net-10 10.0.1.0 10.0.1.255 prefix-length 24
ip nat inside source list 1 pool net-208
ip nat outside source list 1 pool net-10
!
interface gigabitethernet 0/0/0
 ip address 172.31.232.182 255.255.255.240
 ip nat outside
!
interface gigabitethernet 1/1/1
 ip address 10.114.11.39 255.255.255.0
 ip nat inside
!
access-list 1 permit 10.114.11.0 0.0.0.255
```

The following example shows a static VRF aware NAT configuration to translate overlapping local addresses:

```
ip nat inside source static 192.168.121.33 10.2.2.1 vrf vrf1
ip nat inside source static 192.168.121.33.10.2.2.2 vrf vrf2
```

Example: Configuring Dynamic Translation of Inside Source Addresses

The following example shows how inside hosts addressed from either the 192.168.1.0 or the 192.168.2.0 network are translated to the globally unique 172.31.233.208/28 network:

```
ip nat pool net-208 172.31.233.208 172.31.233.223 prefix-length 9
ip nat inside source list 1 pool net-208
!
interface gigabitethernet 0/0/0
 ip address 172.31.232.182 255.255.255.240
 ip nat outside
!
interface gigabitethernet 1/1/1
 ip address 192.168.1.94 255.255.255.0
 ip nat inside
!
access-list 1 permit 192.168.1.0 0.0.0.255
access-list 1 permit 192.168.2.0 0.0.0.255
!
```

The following example shows a dynamic VRF aware NAT configuration to translate overlapping local addresses:

```
ip nat inside source list 1 interface gigabitethernet 0/0/0 vrf vrf1 overload
```

```
!
ip route vrf vrf1 0.0.0.0 0.0.0.0 192.168.1.1
!
access-list 1 permit 10.1.1.1.0 0.0.0.255
!
ip nat inside source list 1 interface gigabitethernet 1/1/1 vrf vrf1 overload
!
ip route vrf vrf1 0.0.0.0 0.0.0.0 172.16.1.1 global
access-list 1 permit 10.1.1.0 0.0.0.255
!
```

Troubleshooting Network Address Translation

This section explains the basic steps to troubleshoot and verify NAT.

- Clearly define what NAT is supposed to achieve.
- Verify that correct translation table exists using the **show ip nat translations** command.
- Verify that correct translation table exists for VRF aware NAT using the **show ip nat translations vrf***vrf-name*command.
- Verify that timer values are correctly configured using the **show ip nat translations verbose** command.
- Check the ACL values for NAT using the **show ip access-list** command
- Check the overall NAT configuration using the **show ip nat statistics** command.
- Use the **clear ip nat translation** command to clear the NAT translational table entires before the timer expires.
- Use **debug nat ip** and **debug nat ip detailed** commands to debug NAT configuration.
- Use the **debug ip nat vrf** *vrf-name* command to troubleshoot issues associated with VRF aware NAT.

For further information on Troubleshooting NAT refer http://www.cisco.com/c/en/us/support/docs/ip/network-address-translation-nat/8605-13.html

Feature History for Network Address Translation

This table provides release and related information for the features explained in this module.

These features are available in all the releases subsequent to the one they were introduced in, unless noted otherwise.

Release	Feature	Feature Information
Cisco IOS XE Everest 16.5.1a	Network Address Translation	NAT enables private IP networks that uses unregistered IP address to connect to the internet. NAT operates on a device, usually connecting two networks together, and translates the private addresses in the internal network into a global routable addresses, before packets are forwarded onto another network. Support for this feature was introduced only on the C9500-12Q, C9500-16X, C9500-24Q, C9500-40X models of the Cisco Catalyst 9500 Series Switches.
Cisco IOS XE Fuji 16.8.1a	Network Address Translation	Support for this feature was introduced only on the C9500-32C, C9500-32QC, C9500-48Y4C, and C9500-24Y4C models of the Cisco Catalyst 9500 Series Switches.
Cisco IOS XE Fuji 16.9.1	Address Only Translation	Address only Translation (AOT) aims to increase the number of IP flows that can be translated and forwarded at line rate in Network Address Translation (NAT). AOT optimizes the usage of hardware resources such as TCAMS and enables the handling of more number of flows.
Cisco IOS XE Gibraltar 16.11.1	Network Address Translation	NAT enables private IP networks that uses unregistered IP address to connect to the internet. NAT operates on a device, usually connecting two networks together, and translates the private addresses in the internal network into a global routable addresses, before packets are forwarded onto another network.
Cisco IOS XE Gibraltar 16.12.1	License level for NAT	NAT is now available on the Network Advantage license. On all earlier releases, it is available on the DNA Advantage license.
Cisco IOS XE Amsterdam 17.2.1	VRF-Aware NAT	VRF support for NAT was introduced.

Use the Cisco Feature Navigator to find information about platform and software image support. To access Cisco Feature Navigator, go to http://www.cisco.com/go/cfn.