Scaling IP Addresses

Accessing the WAN – Chapter 7

Objectives

- Scaling networks with Network Address Translation (NAT) and Port Address Translation (PAT)
- Dynamic Host Configuration Protocol (DHCP)
- Configure new generation RIP (RIPng) to use IPv6

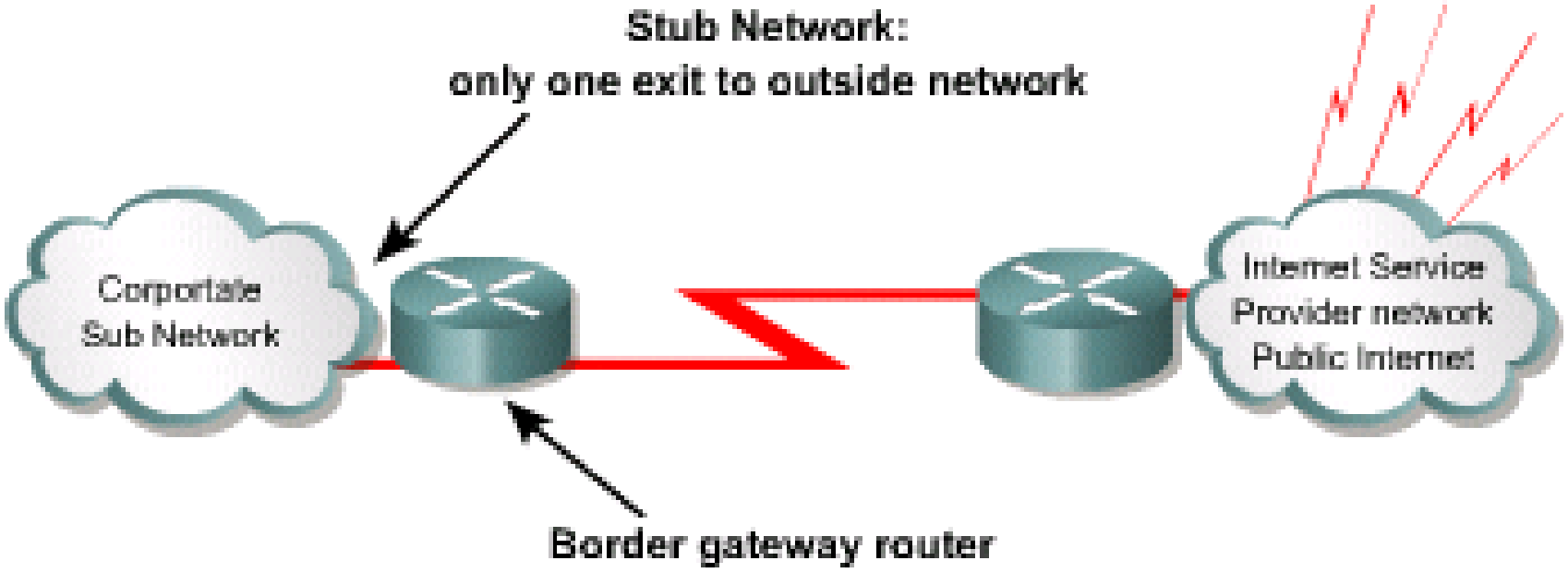
Private Addressing

- Limited number of public addresses
- Private addresses used internal

Class	RFC 1918 Internal Address Range	CIDR Prefix
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

NAT

- Translates private addresses to public
- A NAT-enabled device typically operates at the border of a stub network.



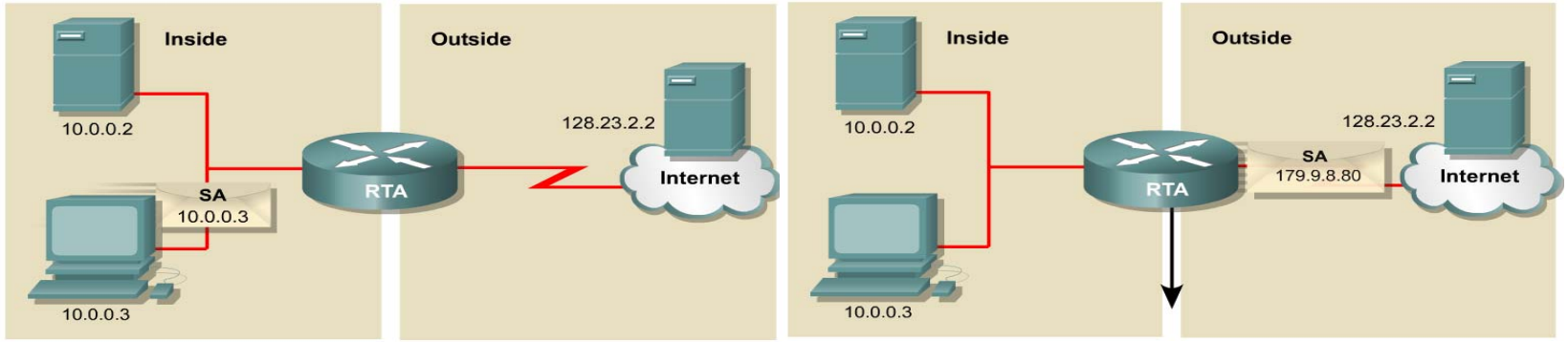
NAT Terminology

- Inside Local Addresses – **An IP address assigned to a host inside a network. This address is likely to be a private address.**
- Inside Global Address – **A legitimate IP address assigned by the NIC or service provider that represents one or more inside local IP address to the outside world.**
- Outside Local Address - **The IP address of an outside host as it is known to the hosts in the inside network.**
- Outside Global Address - **The IP address assigned to a host on the outside network. The owner of the host assigns this address.**

NAT Features

- Static NAT is designed to allow one-to-one mapping of local and global addresses
  - Manually configured
  - Example: Enterprise Server
- Dynamic NAT is designed to map a private IP address to a public address. Uses a pool of addresses and assign them on a first-come, first-served basis
  - Configured on the Border gateway router
  - The router performs the translation

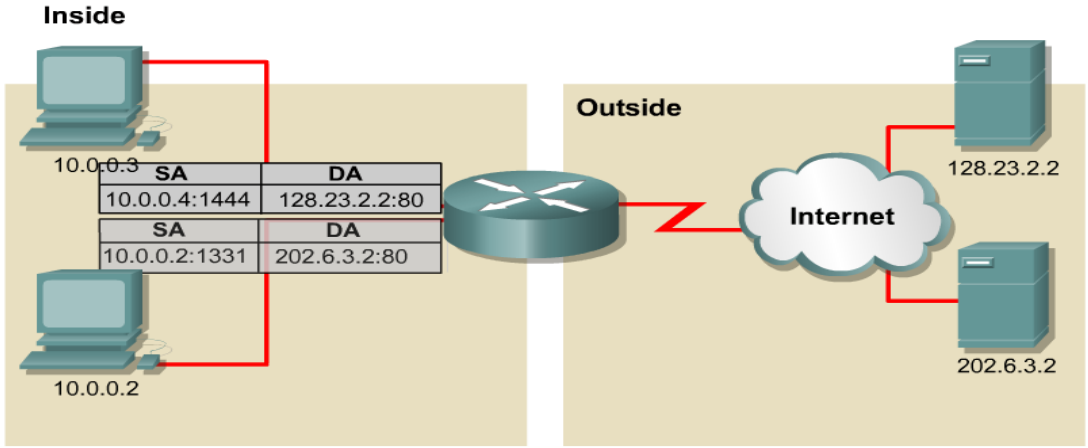
NAT Features



NAT Table		
Inside Local IP Address	Inside Global IP Address	Outside Global IP Address
10.0.0.3	179.9.8.80	128.23.2.2

PAT Features

- PAT uses unique source port numbers on the inside global IP address to distinguish between translations.

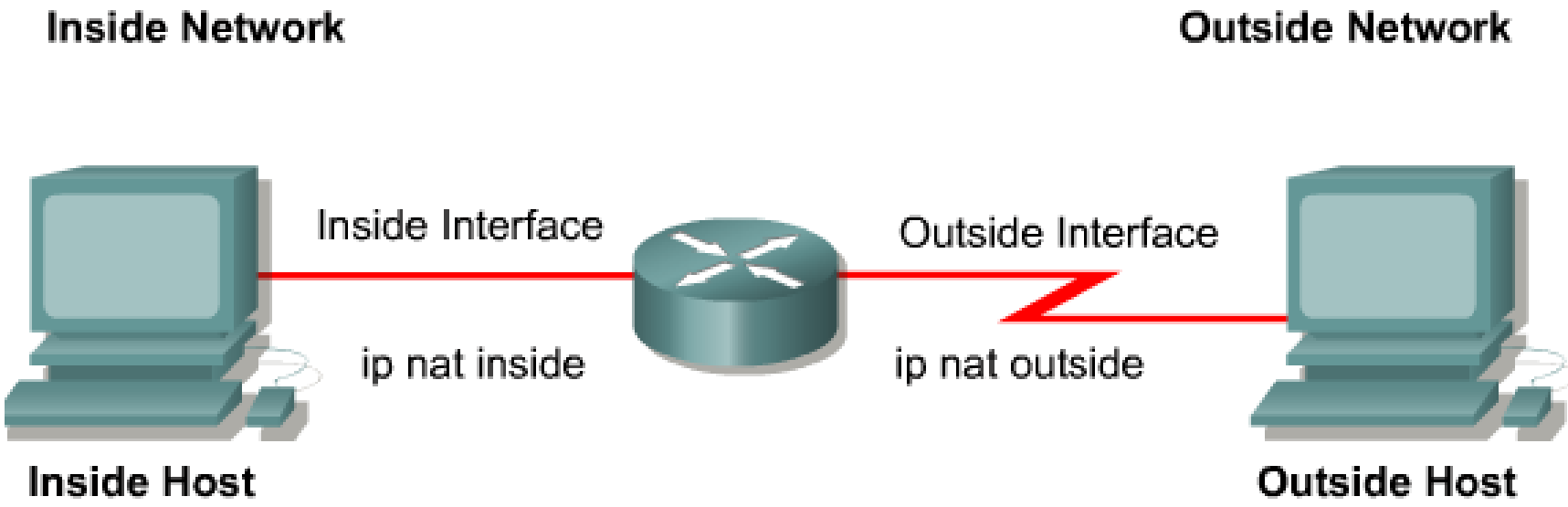


NAT Table			
Inside Local IP Address	Inside Global IP Address	Outside Local IP Address	Outside Global Address
10.0.0.2:1331 10.0.0.3:1555	179.9.8.20:1331 179.9.8.20:1555	202.6.3.2:80 128.23.2.2:80	202.6.3.2:80 128.23.2.2:80

Benefits with NAT/PAT

- Eliminates re-assigning each host a new IP address when changing to a new ISP
- Eliminates the need to re-address all hosts that require external access, saving time and money
- Conserves addresses through application port-level multiplexing
- Protects network security

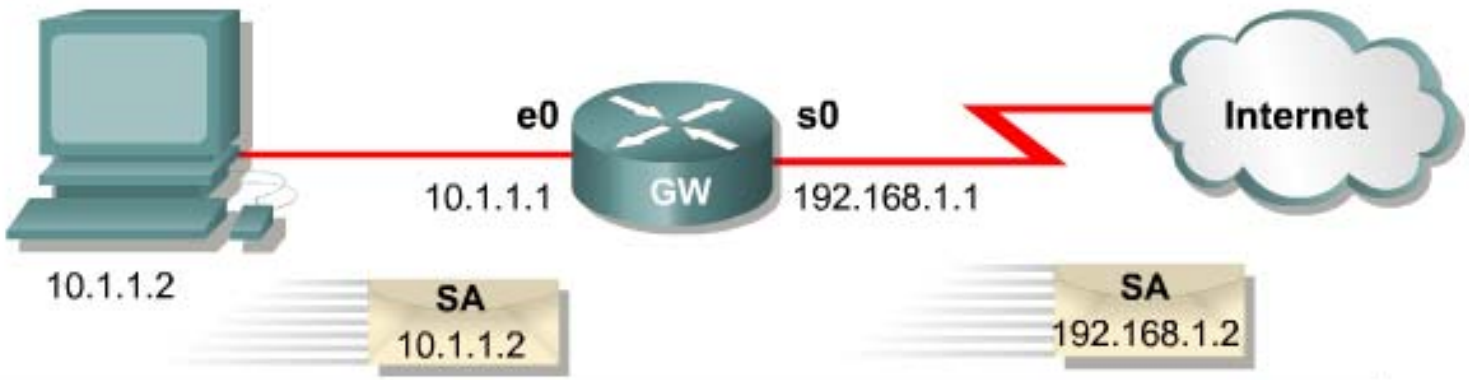
Configuring NAT and PAT




```
Router(config-if)#ip nat inside
```

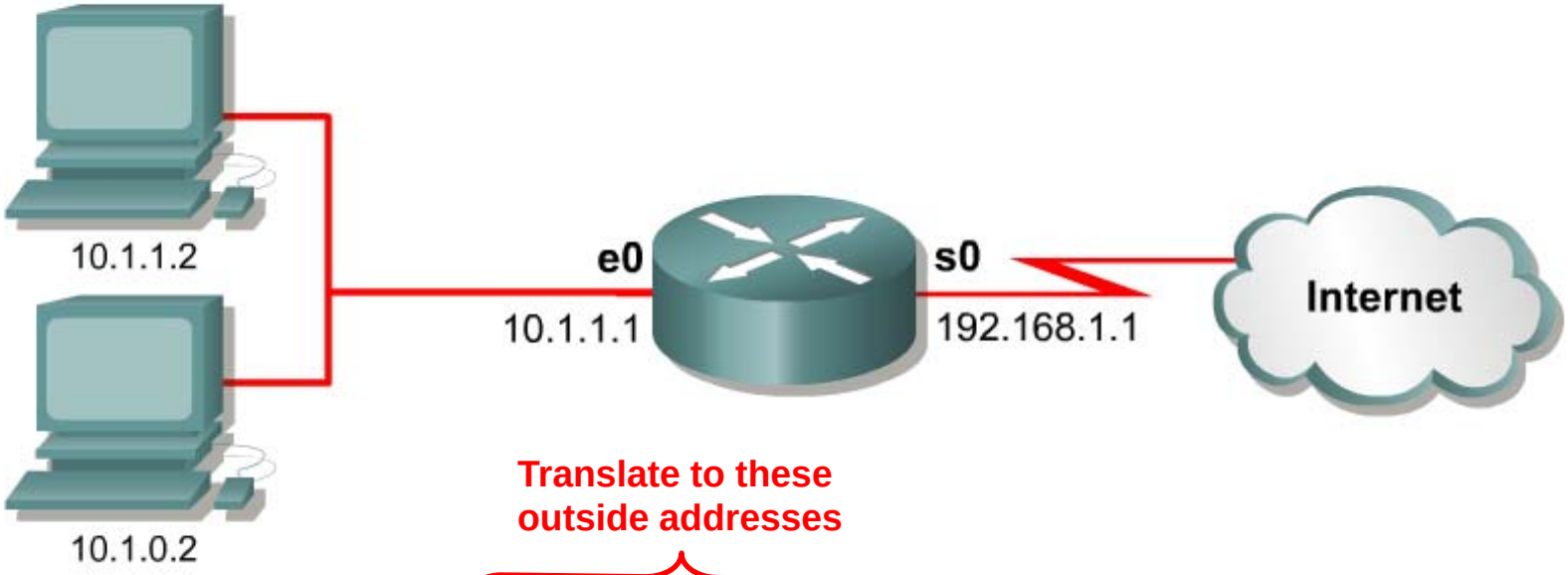
- An interface on the router can be defined as inside or outside.
- Translations occur between inside and outside interfaces.

Configuring Static NAT




```
hostname GW
!
ip nat inside source static 10.1.1.2 192.168.1.2
!
interface ethernet 0
  ip address 10.1.1.1 255.255.255.0
  ip nat inside
!
interface serial 0
  ip address 192.168.1.1 255.255.255.0
  ip nat outside
!
```

Configuring Dynamic NAT



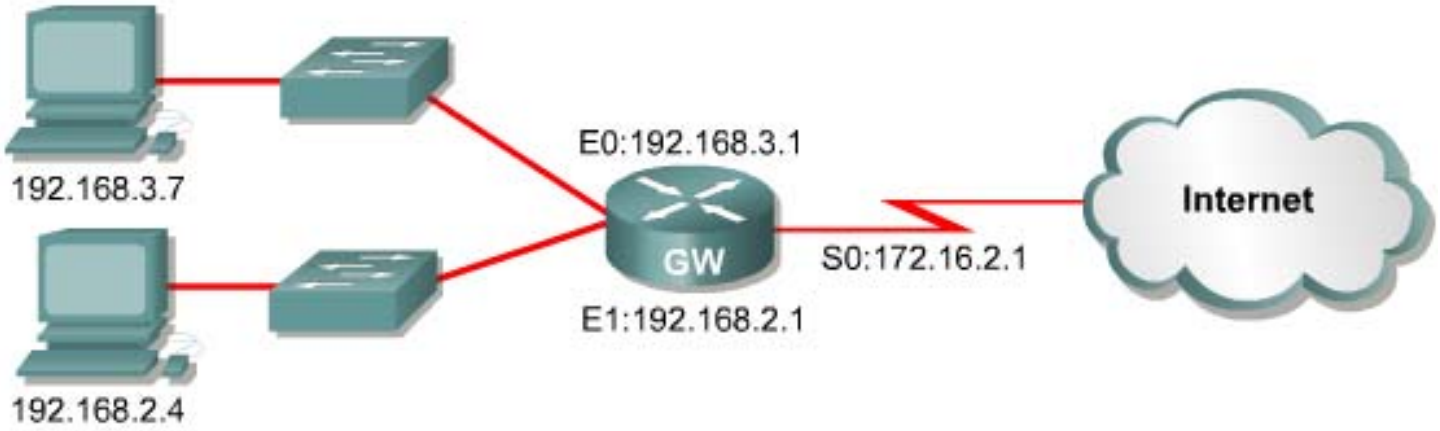
Translate to these outside addresses

Start here

```
ip nat pool nat-pool1 179.9.8.80 179.9.8.95 netmask 255.255.255.0
ip nat inside source list 1 pool nat-pool1
!
interface ethernet 0
  ip address 10.1.1.1 255.255.0.0
  ip nat inside
!
interface serial 0
  ip address 192.168.1.1 255.255.255.0
  ip nat outside
!
access-list 1 permit 10.1.0.0 0.0.0.255
```

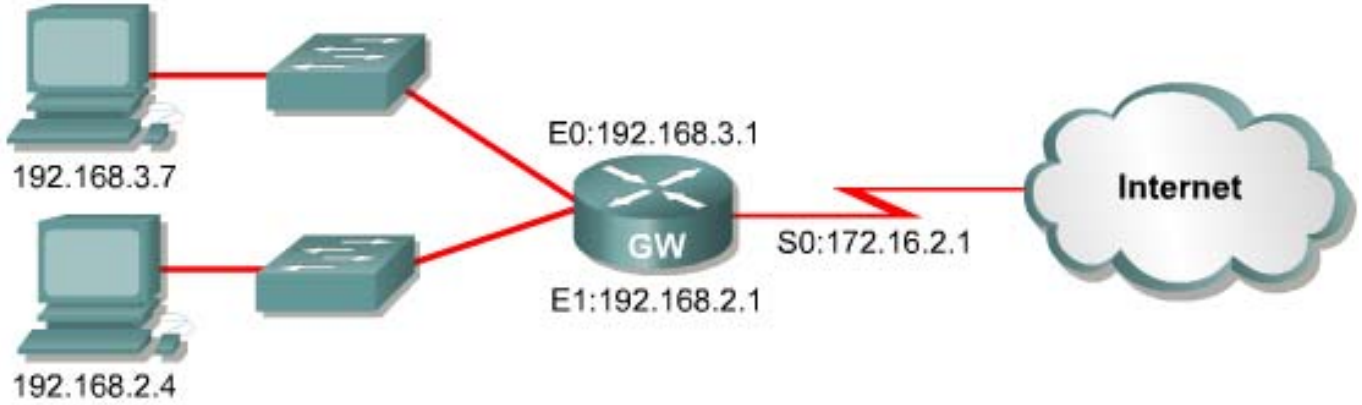
Source IP address must match here

Configuring PAT




```
interface ethernet 0
  ip address 192.168.3.1 255.255.255.0
  ip nat inside
!
interface ethernet 1
  ip address 192.168.2.1 255.255.255.0
  ip nat inside
!
interface serial 0
  ip address 172.16.2.1 255.255.255.0
  ip nat outside
!
ip nat inside source list 1 interface serial 0 overload
!
access-list 1 permit 192.168.2.0 0.0.0.255
access-list 1 permit 192.168.3.0 0.0.0.255
```

Configuring PAT




```
interface ethernet 0
  ip address 192.168.3.1 255.255.255.0
  ip nat inside
!
interface ethernet 1
  ip address 192.168.2.1 255.255.255.0
  ip nat inside
!
interface serial 0
  ip address 172.16.2.1 255.255.255.0
  ip nat outside
!
```

```
ip nat inside source list 1 pool mypool overload
ip nat pool mypool 172.16.3.1 172.1.3.15 netmask 255.255.0.0
access-list 1 permit 192.168.2.0 0.0.0.255
access-list 1 permit 192.168.3.0 0.0.0.255
```

Verifying NAT and PAT Configuration

```
Router#show ip nat translations [verbose]
```

- Displays active translation

```
Router#show ip nat translation
Pro Inside global     Inside local       Outside local      Outside global
172.16.131.1          10.10.10.1              ---                ---
```

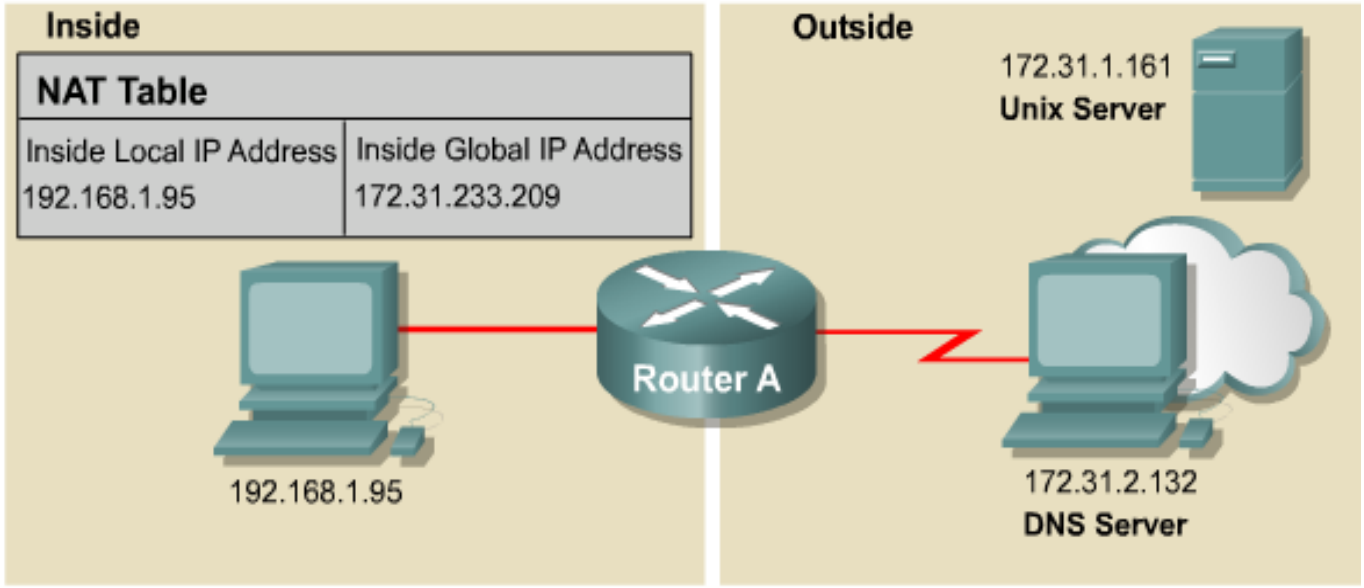
```
Router#show ip nat statistics
```

- Displays translation statistics

```
Router#show ip nat statistics
Total active translations: 1 (1 static, 0 dynamic; 0 extended)
Outside interfaces:
Serial0
Inside interfaces:
Ethernet0, Ethernet1
Hits: 5 Misses:0
```

Command	Description
`show ip nat translations`	Displays active translations
`show ip nat statistics`	Displays translation statistics

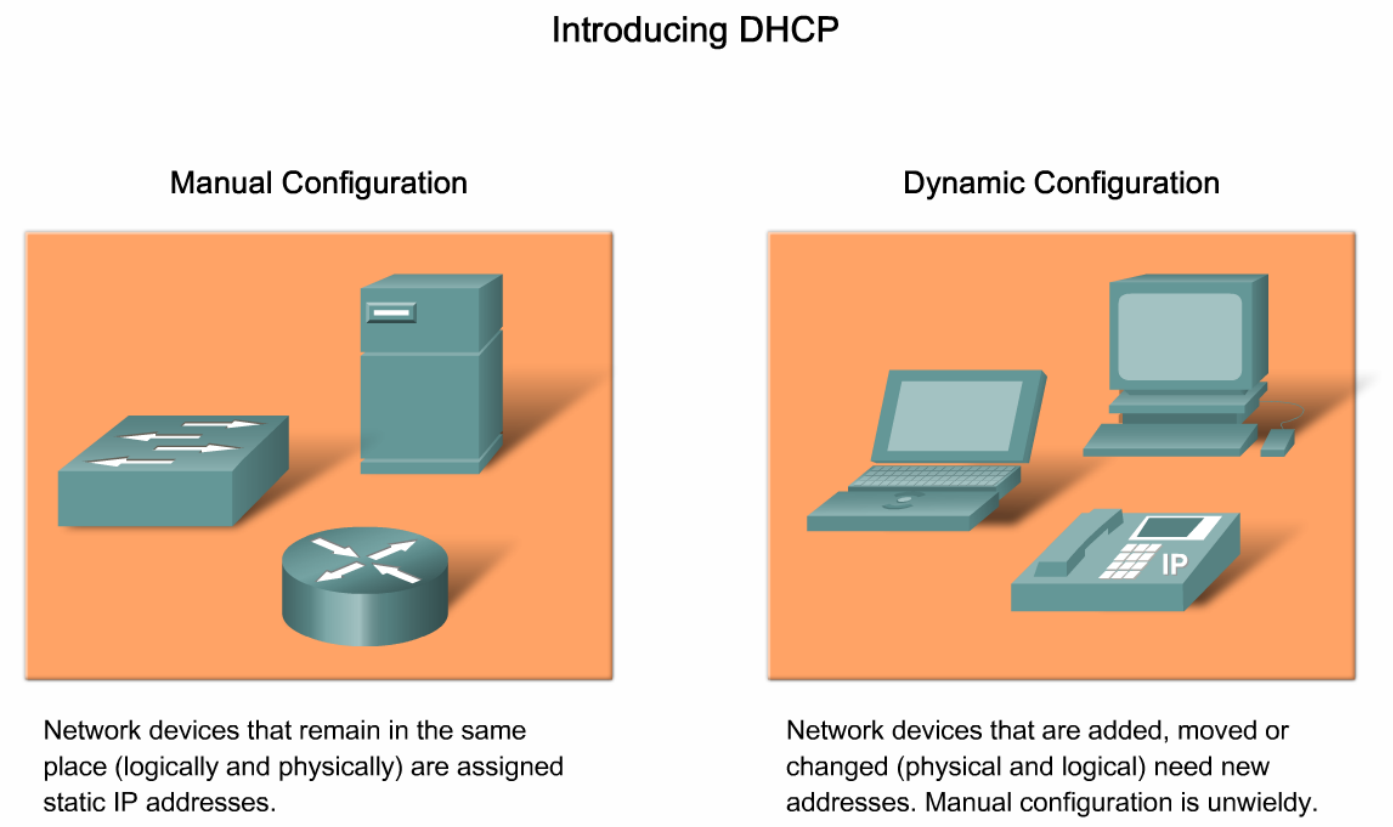
Troubleshooting NAT and PAT




```
RouterA#debug ip nat
NAT:   s= 192.168.1.95    → 172.31.233.209,        d=172.31.2.132 [6825]
NAT:   s= 172.31.2.132,     d=172.31.233.209,    → 192.168.1.95 [21852]
NAT:   s= 192.168.1.95    → 172.31.233.209,        d=172.31.1.161 [6826]
NAT*:  s= 172.31.1.161,     d=172.31.233.209,    → 192.168.1.95 [23311]
NAT*:  s= 192.168.1.95    → 172.31.233.209,        d=172.31.1.161 [6827]
NAT*:  s= 192.168.1.95    → 172.31.233.209,        d=172.31.1.161 [6828]
NAT*:  s= 172.31.1.161      d=172.31.233.209,    → 192.168.1.95 [23313]
NAT*:  s= 172.31.1.161,     d=172.31.233.209,    → 192.168.1.95 [23313]
```

Dynamic Host Configuration Protocol (DHCP)

- The function of DHCP in a network



Dynamic Host Configuration Protocol (DHCP)

- Works in a client/server mode
- Enable clients to obtain their configurations from server
- Less work
- Most significant configuration option: IP-addresses

DHCP

- DHCP works by providing a process for a server to allocate the IP information to clients
- Pre-defined pools of addresses in DHCP server
- Scalable and easy to manage
- Clients lease the information from the server for an administratively defined period
- Offers other information; DNS server address, domain name etc.

DHCP

Ethernet Frame	IP	UDP	DHCP Request
SRC MAC: MAC A DST MAC: FF:FF:FF:FF:FF:FF	IP SRC: ? IP DST: 255.255.255.255	UDP 67	CIADDR: ? GIADDR: ? Mask:? CHADDR: MAC A

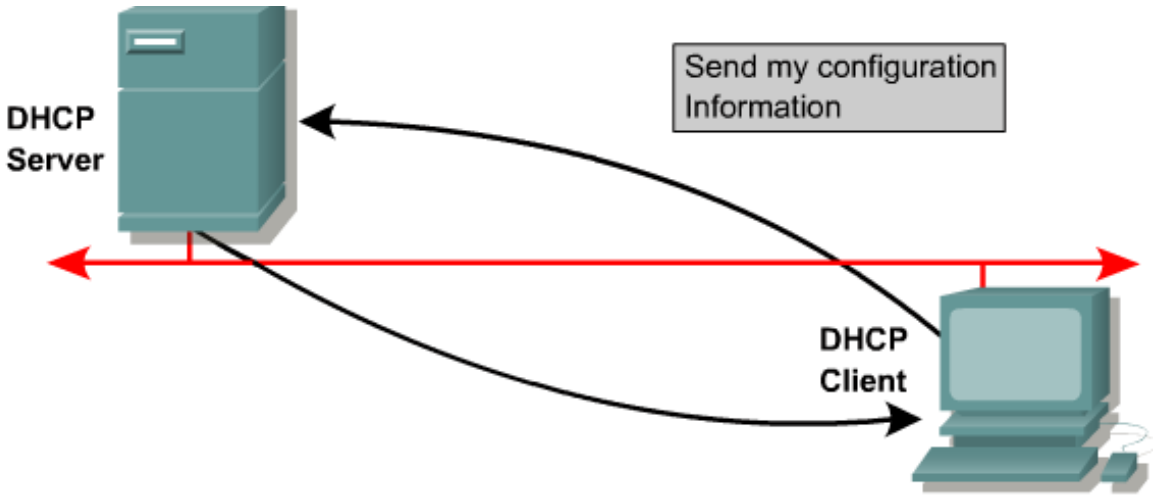
MAC: Media Access Control Address
CIADDR: Client IP Address
GIADDR: Gateway IP Address
CHADDR: Client Hardware Address

Ethernet Frame	IP	UDP	DHCP Reply
SRC MAC: MAC Serv DST MAC: MAC A	IP SRC: 192.168.1.254 IP DST: 192.168.1.10	UDP 68	CIADDR: 192.168.1.10 GIADDR: ? Mask: 255.255.255.0 CHADDR: MAC A

MAC: Media Access Control Address
CIADDR: Client IP Address
GIADDR: Gateway IP Address
CHADDR: Client Hardware Address

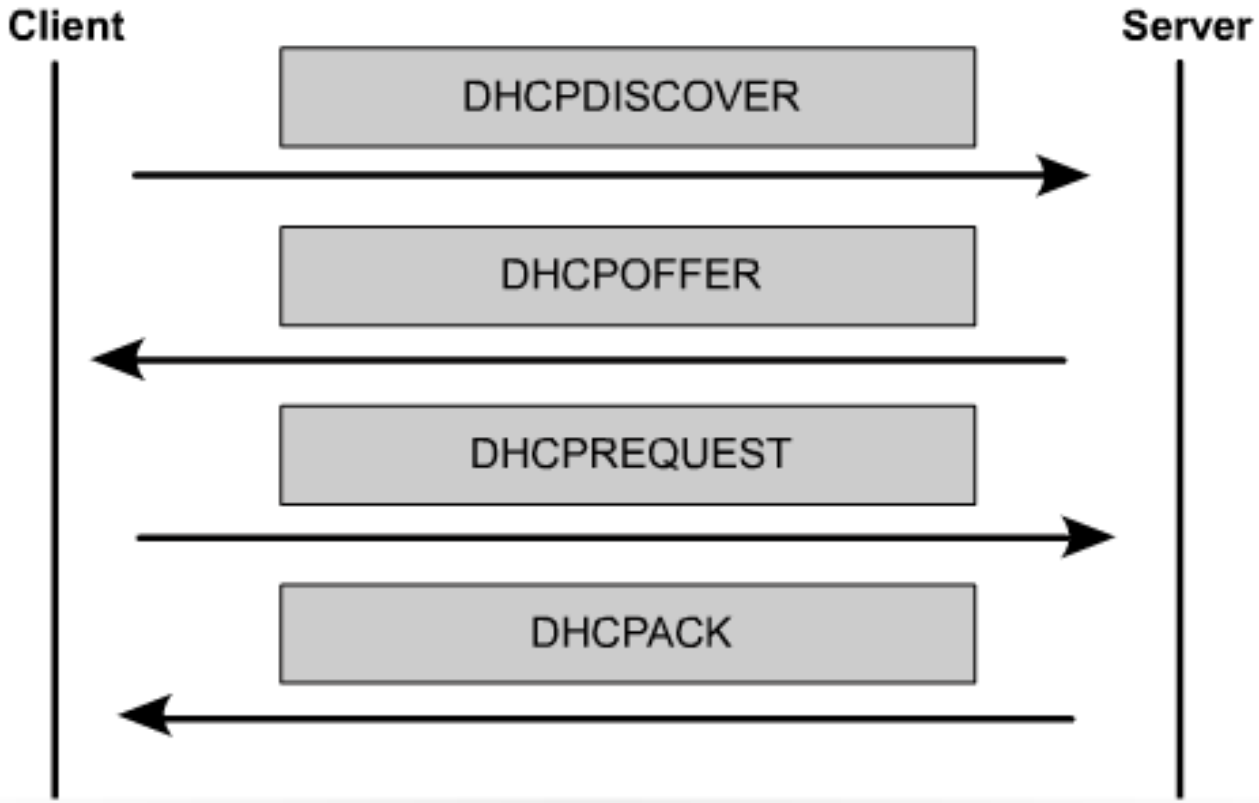
Major DHCP Features

- Automatic Allocation
- Manual Allocation
- Dynamic Allocation



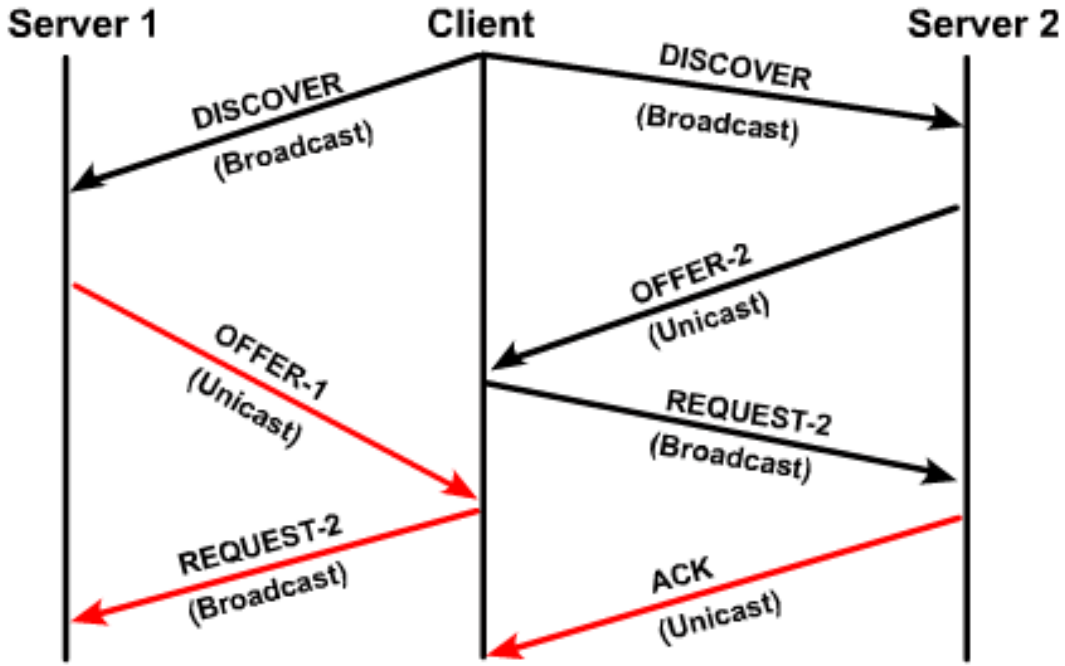

```
Here is Your Configuration:
• IP Address: 192.204.18.7
• Subnet Mask: 255.255.255.0
• Default Routers: 192.204.18.1, 192.204.18.3
• DNS Servers: 192.204.18.8, 192.204.18.9
• Lease Time: 5 days
```

The Order of DHCP Messages Transmitting



DHCP messages in the order they are transmitted

DHCP Operation



- DHCP client broadcasts DHCP DISCOVER packet on local subnet
- DHCP servers send OFFER packet with lease information
- DHCP client selects lease and broadcasts DHCP REQUEST packet
- Selected DHCP server sends DHCP ACK packet

Configuring DHCP

```
Router(config)#ip dhcp pool pool-name1
```

Specify the DHCP pool

```
Router(dhcp-config)#network ip-address mask
```

Specify the range of addresses in the pool

- Creates an IP DHCP pool, and gives it a name
- Up to multiple DHCP pools can be created on one server
- Specify the IP range of addresses using an IP network address and mask

Configuring DHCP While Excluding IP

```
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)# domain-name span.com
R1(dhcp-config)# end
```

Verifying DHCP

```
Router#show ip dhcp binding
```

```
Router#show ip dhcp binding
IP address      Hardware address    Lease expiration        Type
172.16.12.11    0100.10a4.97f4.6d   Mar 02 1993 12:38 AM    Automatic
Router#
```

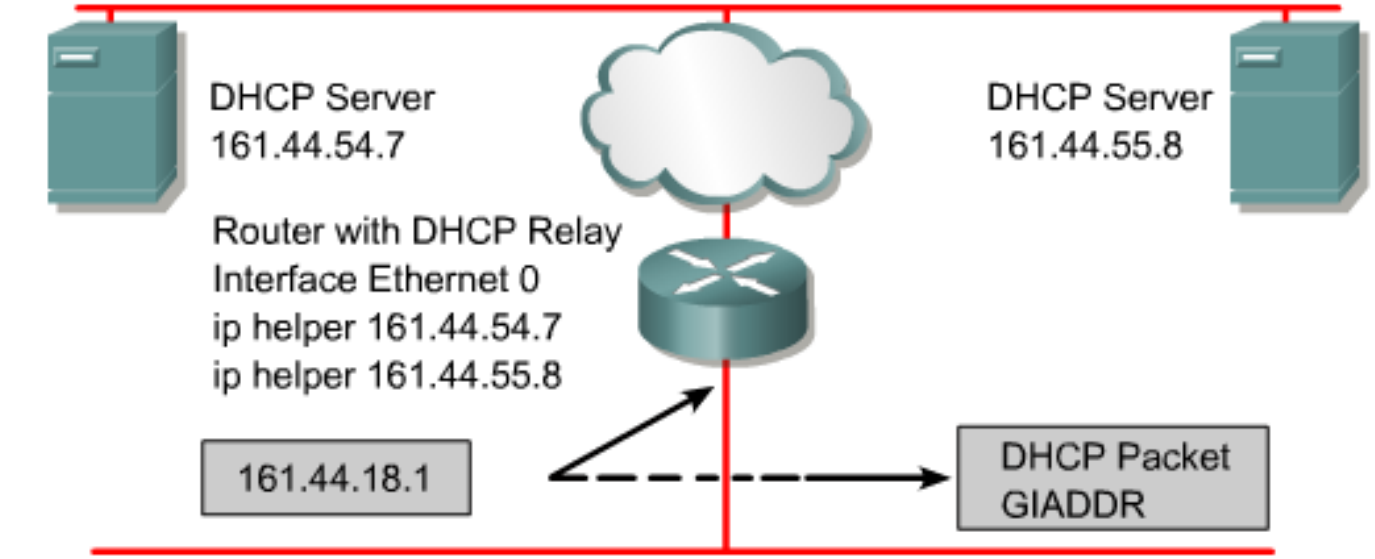
Router# show ip dhcp server statistics

Troubleshooting DHCP

```
Router#debug ip dhcp server events
```

```
Router#debug ip dhcp server events
Router#
00:22:53: DHCPD:checking for expired leases.
00:22:23: DHCPD: assigned IP address 172.16.13.11 to client
0100.10a4.97f4.6d
00:22:49: DHCPD:retured 172.16.13.11 to address pool remote.
00:22:59: DHCPD: assigned IP address 172.16.13.11 to client
0100.10a497f4.6d.
```

DHCP Relay



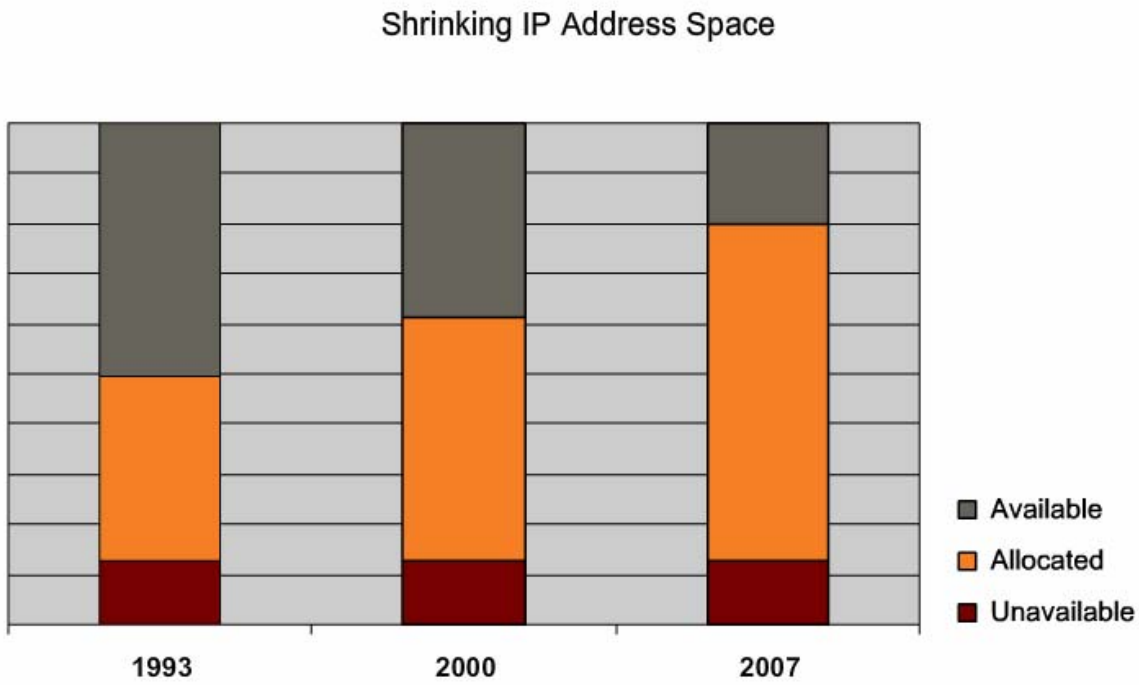
Physical Network
161.44.18.0

DHCP Client

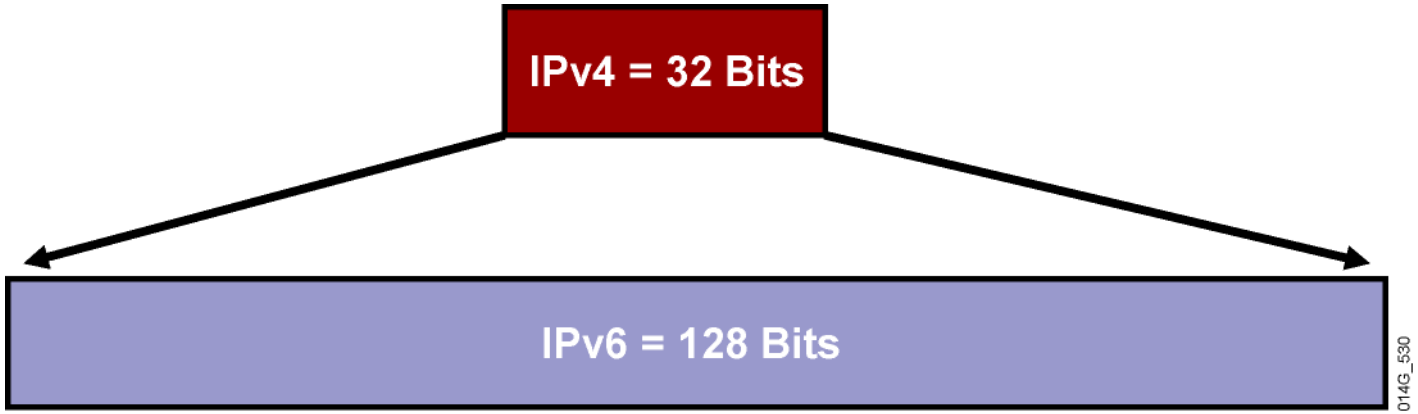
- DHCP clients broadcasts a DHCP discover packet.
- DHCP relay (ip helper address) on the router hears the DHCP. Discover packet and fowards (unicast) the packet to the DHCP server.
- DHCP relay fills in the GIADDR field with IP address primary interface of router.
- DHCP relay can be configured to forward the packet to multiple DHCP servers; client will choose the "best" server.

IPv6

- Number of users on the Internet grows
- IPv6 satisfies the increasingly complex requirements of hierarchical addressing that IPv4 does not provide



IPv6 - Larger Address Space



IPv4

- 32 bits or 4 bytes long
  - ≅ 4,200,000,000 possible addressable nodes

IPv6

- 128 bits or 16 bytes: four times the bits of IPv4
  - ≅ $3.4 * 10^{38}$ possible addressable nodes
  - ≅ 340,282,366,920,938,463,374,607,432,768,211,456
  - ≅ $5 * 10^{28}$ addresses per person

IPv6 - Format

IPv6 Address Representation

IPv6 Formats

Format:

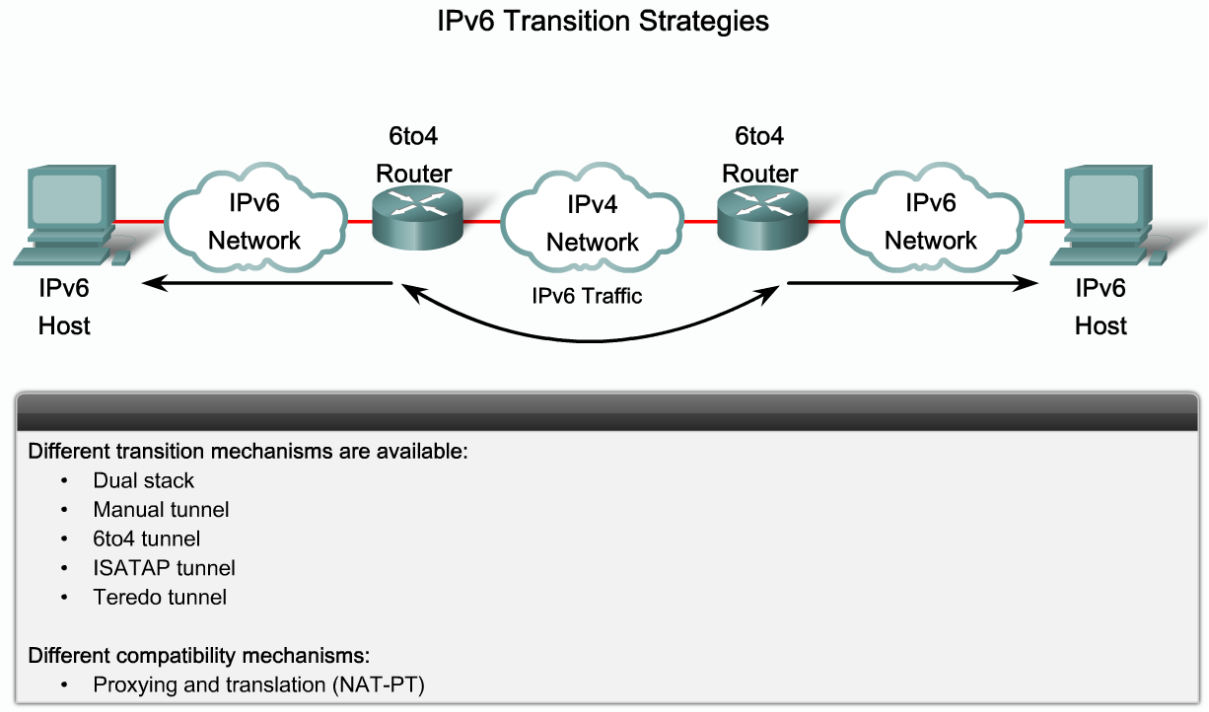
- **x:x:x:x:x:x:x:x**, where x is a 16-bit hexadecimal field
  - Case-insensitive for hexadecimal A, B, C, D, E, and F
- Leading zeros in a field are optional
- Successive fields of zeros can be represented as **::** only once per address

Examples:

- **2031:0000:130F:0000:0000:09C0:876A:130B**
  - Can be represented as **2031:0:130f::9c0:876a:130b**
  - Cannot be represented as **2031::130f::9c0:876a:130b**
- **FF01:0:0:0:0:0:0:1** **FF01::1**
- **0:0:0:0:0:0:0:1** **::1**
- **0:0:0:0:0:0:0:0** **::**

IPv6 Transition Strategies

- Different methods to implement IPv6
- Most common: Dual stack and Tunneling



IPv6 Transition Strategies

- Dual Stack
  - Routers and switches are configured to support both IPv4 and IPv6 protocols
  - IPv6 preferred
- Tunneling
  - Several tunneling techniques available
  - IPv6 packets are encapsulated within the IPv4 protocol

New Generation RIP (RIPng) to use IPv6

- Existing routing protocols are modified to support IPv6
- Longer addresses

  address header field increased from 64 bits to 256 bits

Similar IPv4 features:

- Distance vector, radius of 15 hops, split horizon, and poison reverse
- Based on RIPv2

Updated features for IPv6:

- IPv6 prefix, next-hop IPv6 address
- Uses the multicast group FF02::9, the all-rip-routers multicast group, as the destination address for RIP updates
- Uses IPv6 for transport
- Named RIPng

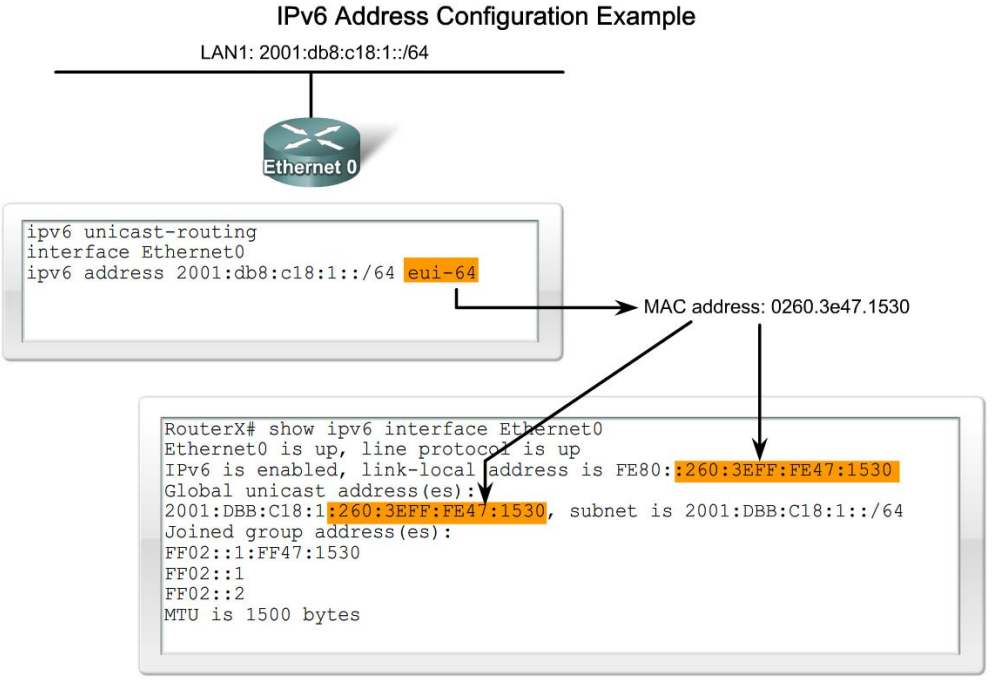
Configure IPv6 Addresses

- Two basic steps

  -Activate IPv6 traffic forwarding

  -Configure each interface

  that requires IPv6



Enabling IPv6 on Cisco I

Command	Purpose
RouterX(config)# ipv6 unicast-routing	Enables IPv6 traffic forwarding
RouterX(config-if)# ipv6 address ipv6prefix/prefix-length eui-64	Configures the interface IPv6 addresses

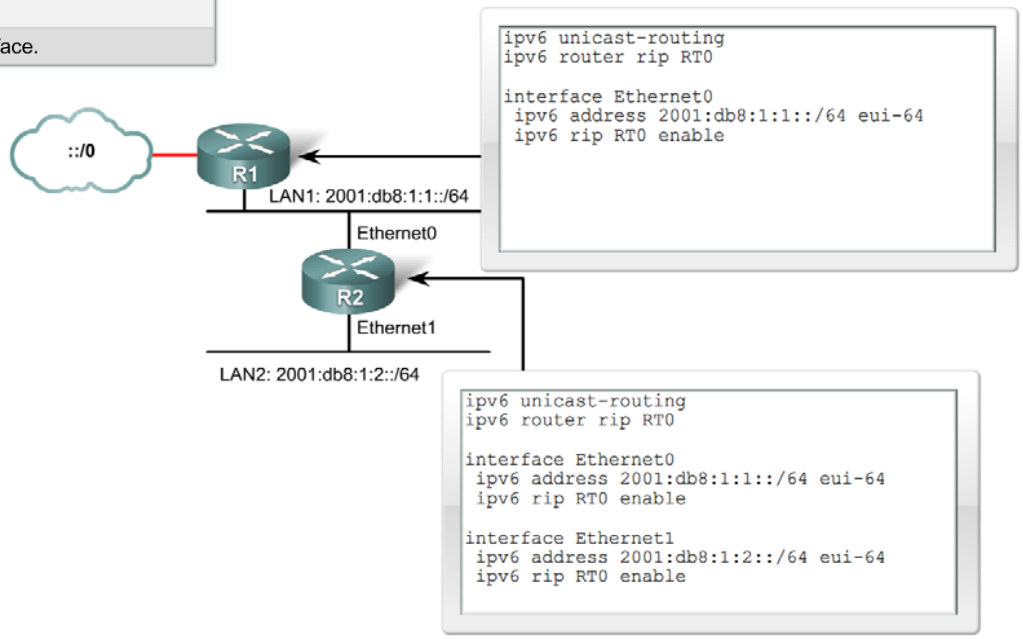
Configure RIPng with IPv6

- Create routing process
- Enable routing process on interfaces

Configuring RIPng for IPv6

Command	Purpose
RouterX(config)#**ipv6 router rip** *name*	Creates and enters RIP router configuration mode.
RouterX(config-if)#**ipv6 rip** *name* **enable**	Configures RIP on an interface.

RIPng for IPv6 Configuration



Summary

- Private IP addresses
  - –Class A = 10.x.x.x
  - –Class B = 172.16.x.x – 172.31.x.x
  - –Class C = 192.168.x.x
- Network Address Translation (NAT)
  - –A means of translating private IP addresses to public IP addresses
  - –Types of NAT
    - •Static
    - •Dynamic
  - –Some commands used for troubleshooting
    - •Show ip nat translations
    - •Show ip nat statistics
    - •Debug ip nat

Summary

- Dynamic Host Control Protocol (DHCP)

  This is a means of assigning IP address and other configuration information automatically.

- DHCP operation

  –3 different allocation methods

  - Manual
  - Automatic
  - Dynamic

  –Steps to configure DHCP

  - Define range of addresses
  - Create DHCP pool
  - Configure DHCP pool specifics

Summary

- DHCP Relay

  Concept of using a router configured to listen for DHCP messages from DHCP clients and then forwards those messages to servers on different subnets

- Troubleshooting DHCP

  –Most problems arise due to configuration errors

  –Commands to aid troubleshooting

    •Show ip dhcp

    •Show run

    •debug

Summary

- IPv6
  - –A 128 bit address that uses colons to separate entries
  - –Normally written as 8 groups of 4 hexadecimal digits
- Cisco IOS Dual Stack
  - –A way of permitting a node to have connectivity to an IPv4 & IP v6 network simultaneously
- IPv6 Tunneling
  - –An IPV6 packet is encapsulated within another protocol

Summary

- Configuring RIPng with IPv6
  - 1st globally enable IPv6
  - 2nd enable IPv6 on interfaces on which IPv6 is to be enabled
  - 3rd enable RIPng using
    - global: ipv6 router rip *name*
    - interface: ipv6 router *name* enable