

NAT & IPv6 | Neso Academy

 nesoacademy.org/cs/06-computer-networks/ppts/06-nat&ipv6



NAT & IPv6 Neso Academy CHAPTER - 6

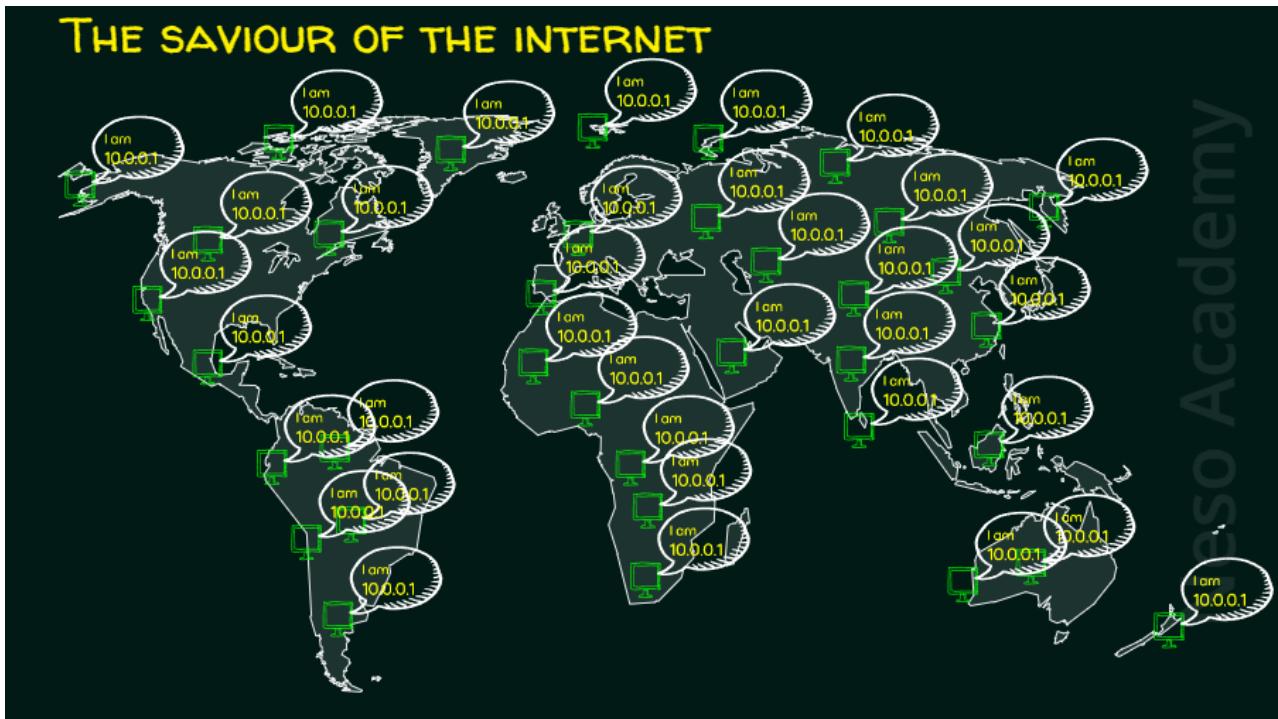
OUTCOMES

Upon the completion of this lecture, the learner will be able to

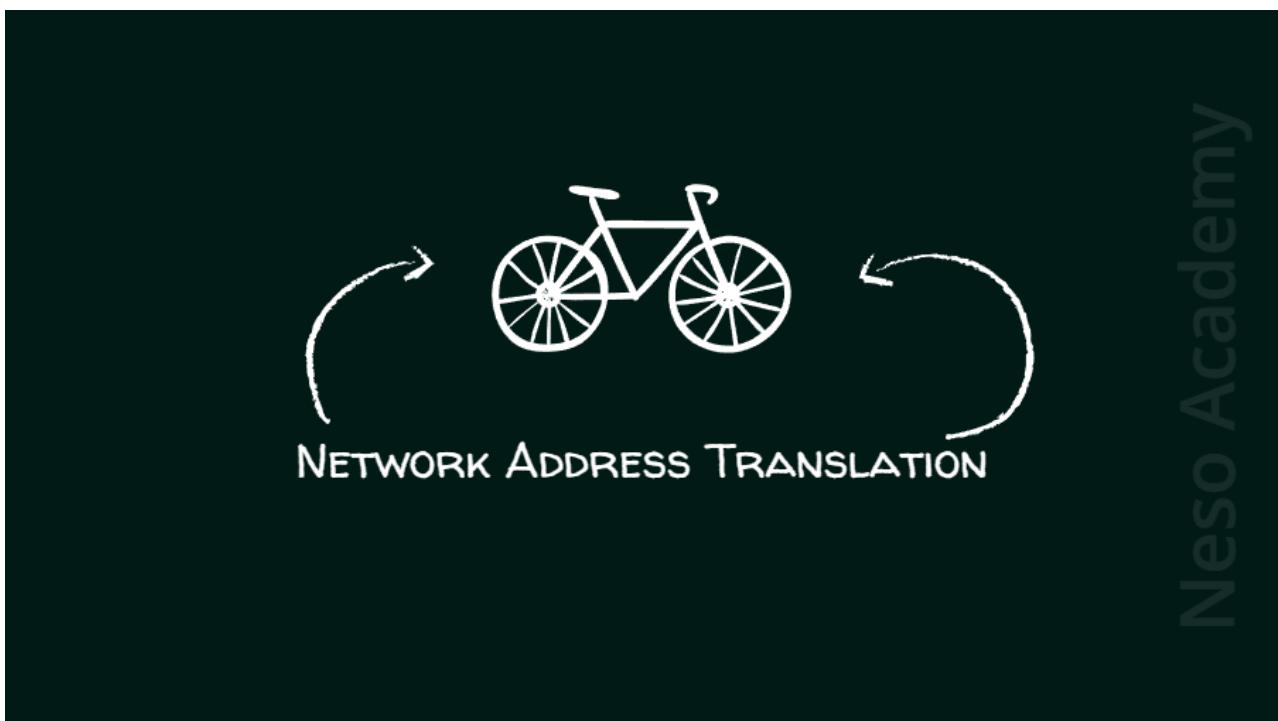
- ★ Know the limitations of private IP addresses.
- ★ Understand the need for NAT.
- ★ Understand the basic operation of NAT and NAT translations.

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Outcomes ★★★ Neso Academy

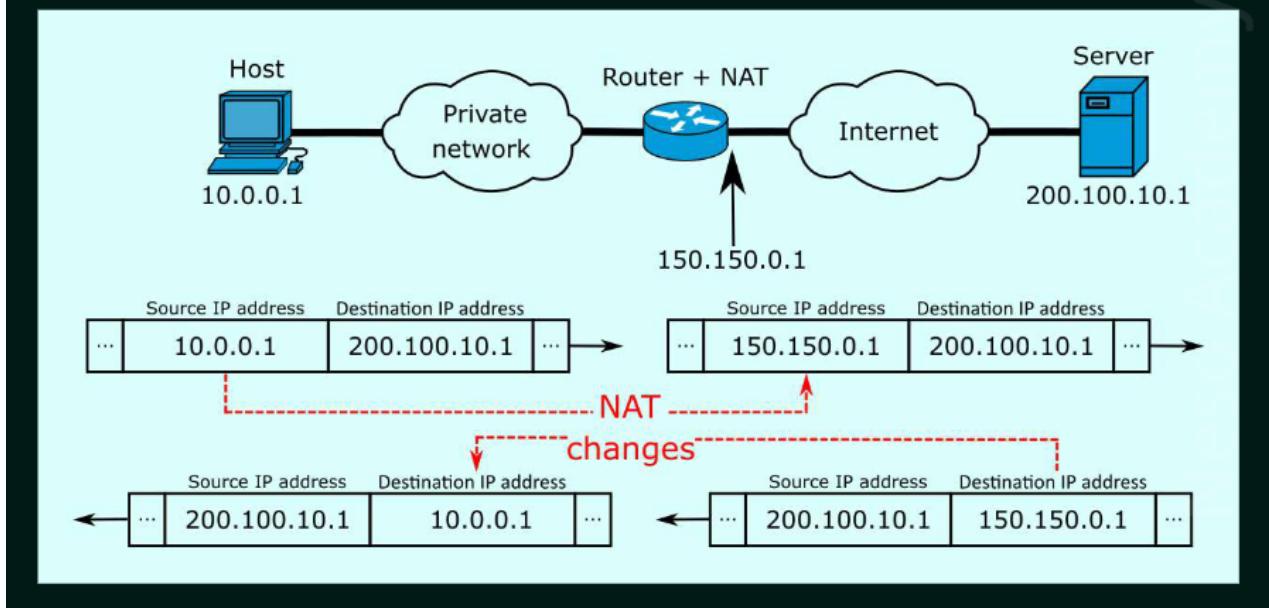


The saviour of the internetNeso Academy

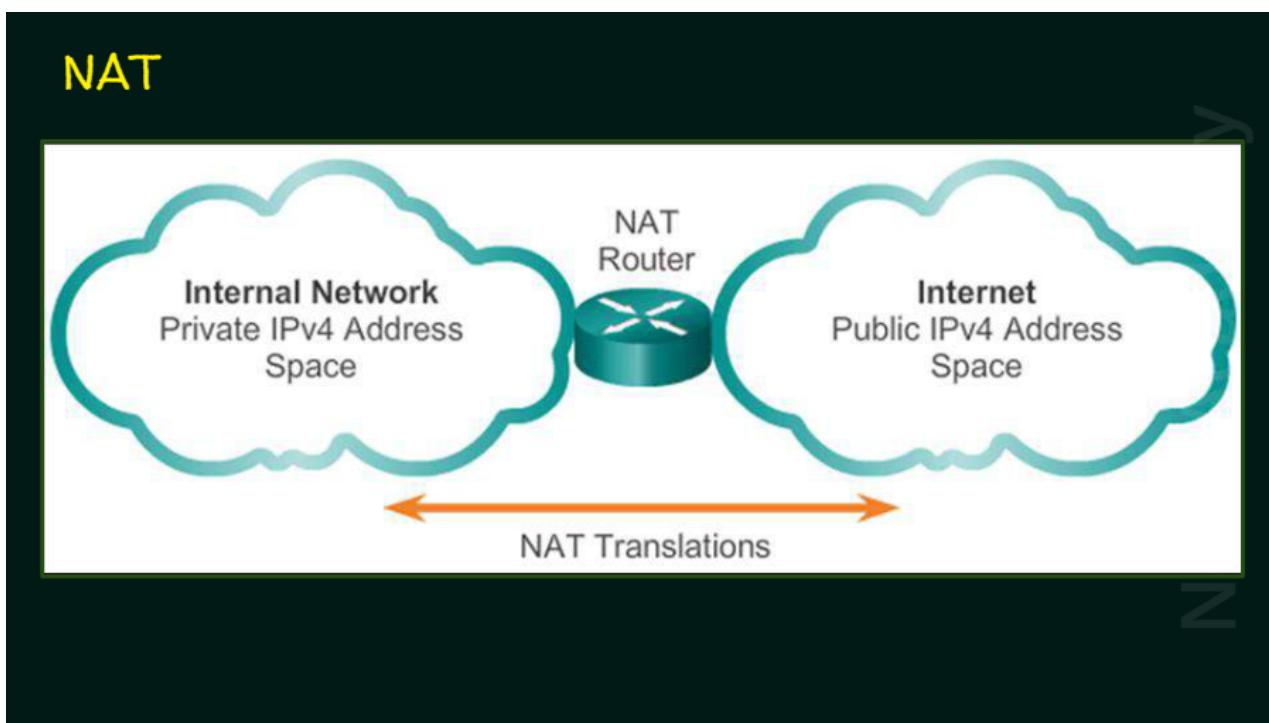


Network Address TranslationNeso Academy

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NATNeso Academy

NAT

- ★ IPv4 address space is not big enough to uniquely address all the devices that must be connected to the Internet.
- ★ Network private addresses are described in RFC 1918 and are designed to be used within an organization or site only.
- ★ Private addresses are not routed by Internet routers while public addresses are routed by the Internet routers.
- ★ Private addresses can alleviate IPv4 scarcity, but because they aren't routed by Internet devices, they first need to be translated.
- ★ NAT is process used to perform such translation.
- ★ NAT = Network Address Translation.

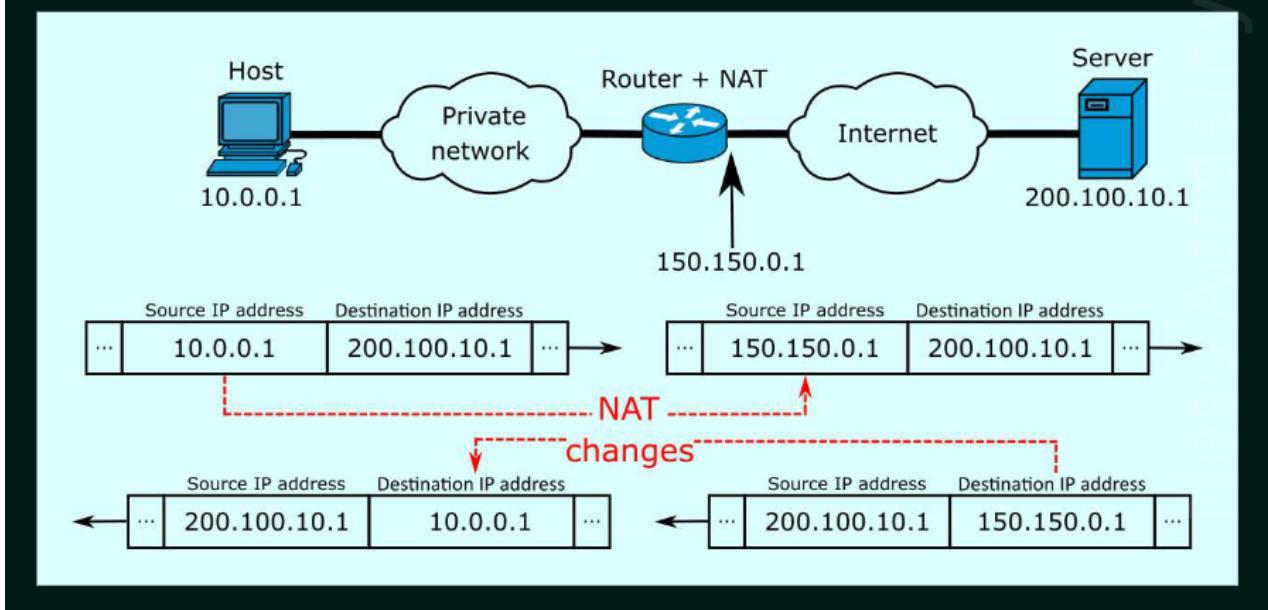
NAT★★★★★Neso Academy

NAT

- ★ NAT is a process used to translate network addresses.
- ★ NAT's primary use is to conserve public IPv4 addresses.
- ★ NAT is usually implemented at border network devices, such as firewalls or routers.
- ★ NAT allows the networks to use private addresses internally, only translating to public addresses when needed.
- ★ Devices within the organization can be assigned private addresses and operate with locally unique addresses.
- ★ When traffic must be sent or received to or from other organizations or the Internet, the border router translates the addresses to a public and globally unique address.

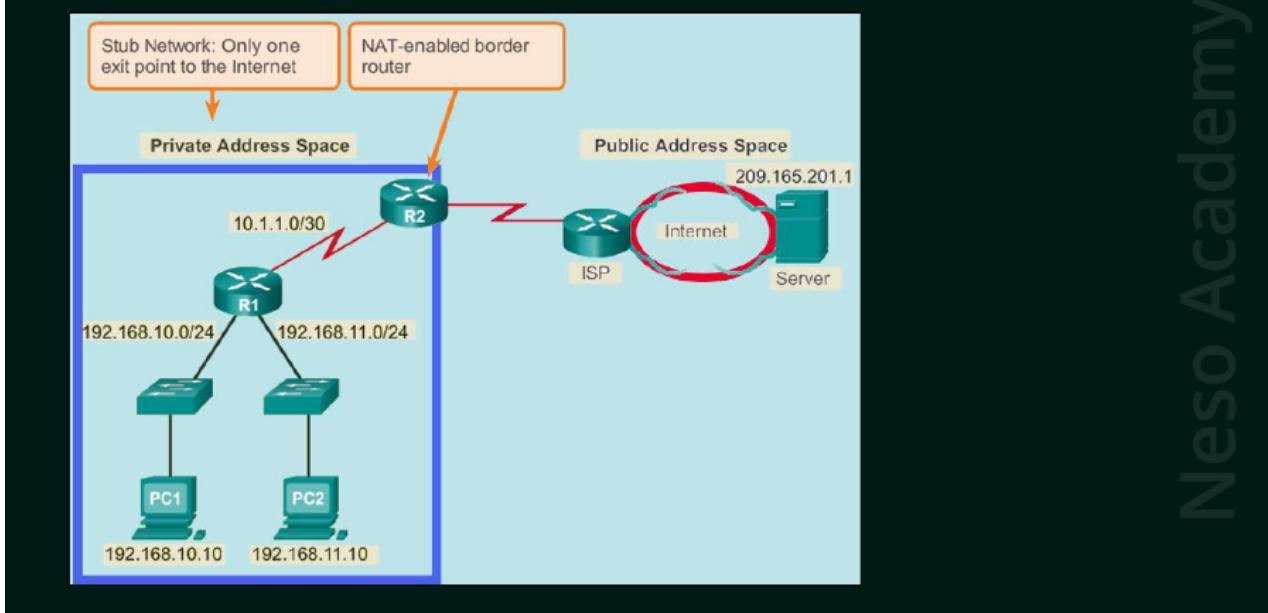
NAT★★★★★Neso Academy

NAT – THE SAVIOUR OF THE INTERNET



NAT -The saviour of the internetNeso Academy

NAT – THE SAVIOUR OF THE INTERNET

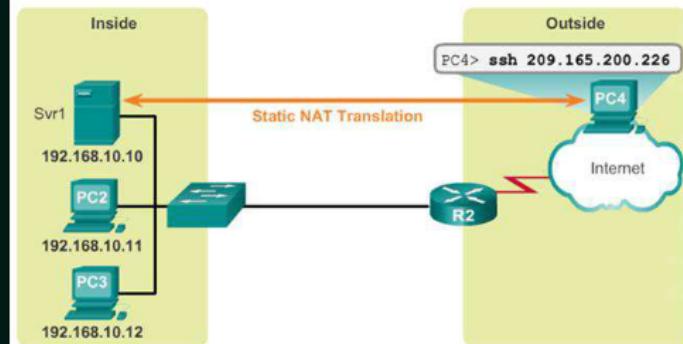


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TYPES OF NAT

- ★ Static NAT
- ★ Dynamic NAT
- ★ PAT

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

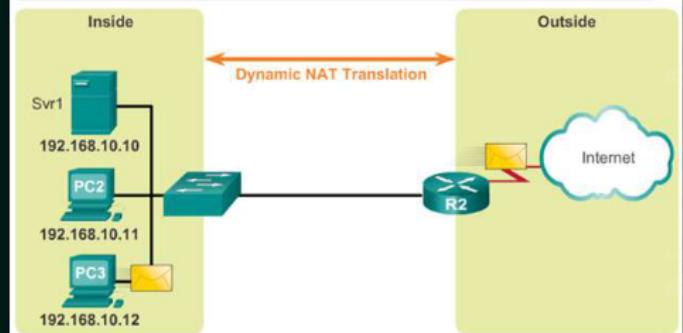


Types of NAT★★★Neso Academy

TYPES OF NAT

- ★ Static NAT
- ★ Dynamic NAT
- ★ PAT

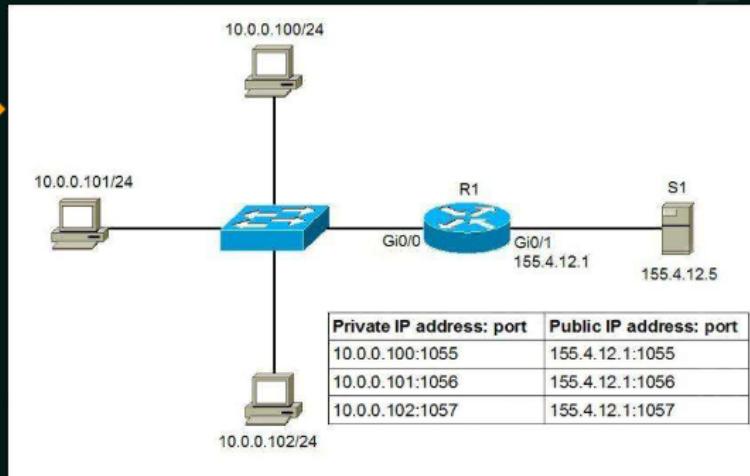
IPv4 NAT Pool	
Inside Local Address	Inside Global Address Pool - Addresses reachable via R2
192.168.10.12	209.165.200.226
Available	209.165.200.227
Available	209.165.200.228
Available	209.165.200.229
Available	209.165.200.230



Types of NAT★★★Neso Academy

TYPES OF NAT

- ★ Static NAT
- ★ Dynamic NAT
- ★ PAT 



Types of NAT★★★Neso Academy

OUTCOMES

Upon the completion of this lecture, the learner will be able to

- ★ Know the limitations of IPv4.
- ★ Understand the need for IPv6.
- ★ Know the features of IPv6.

Outcomes★★★Neso Academy

LIMITATIONS OF IPv4

- ★ IP Address depletion: 4 billion IPv4 addresses – 4,294,967,296.
- ★ Internet routing table expansion.
- ★ Lack of end-to-end connectivity.

Limitations of IPv4 ★★★ Neso Academy

REALLY HUGE

Total No. of Addresses: 2^{32} in IPv4 and 2^{128} in IPv6

340,282,366,920,938,463,463,374,607,431,768,211,456

Whoa! That's a big number, aren't you proud?

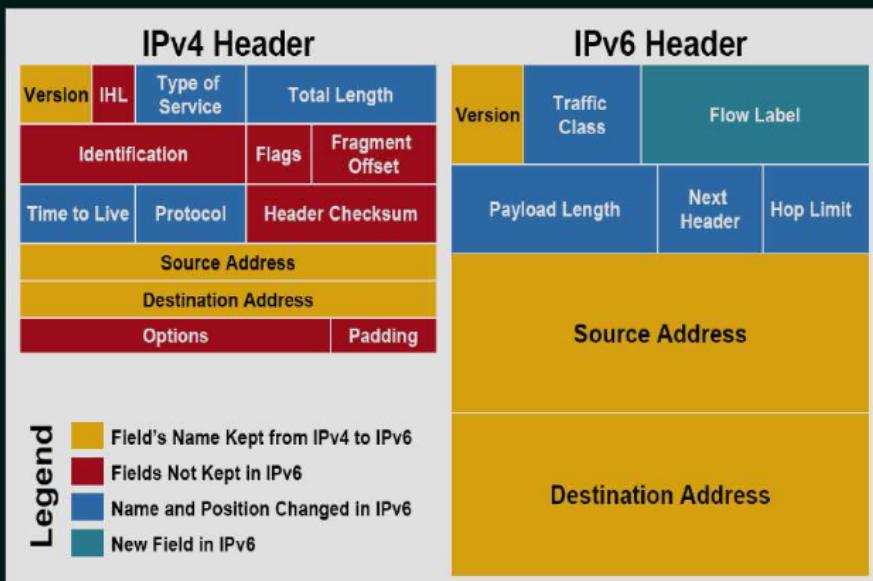
reallyHUGENeso Academy

FEATURES OF IPv6

- ★ Increased address space (128 bit address) - 340 undecillion IPv6 addresses
- ★ Improved packet handling
- ★ Eliminates the need for NAT
- ★ Integrated security
- ★ Autoconfiguration
- ★ End-to-End fragmentation
- ★ Enhanced routing functionality, including support for mobile hosts

Features of IPv6 ★★★★★ Neso Academy

IPv4 AND IPv6 HEADER



IPv4 and IPv6 Header Neso Academy

HEXADECIMAL NUMBER SYSTEM

Hexadecimal	Decimal	Binary
0	0	0000
1	1	0001
2	2	0010
3	3	0011
4	4	0100
5	5	0101
6	6	0110
7	7	0111
8	8	1000
9	9	1001
A	10	1010
B	11	1011
C	12	1100
D	13	1101
E	14	1110
F	15	1111

Hexadecimal Number System Neso Academy

IPv6 ADDRESS NOTATION

- ★ Notation: x:x:x:x:x:x:x:x (x = 16-bit hex number)
- ★ 128 bits in length and written as a string of hexadecimal values
- ★ In IPv6, 4 bits represents a single hexadecimal digit, 32 hexadecimal value = IPv6 address
- ★ 2001:0DB8:0000:1111:0000:0000:0000:0200
- ★ FE80:0000:0000:0000:0123:4567:89AB:CDEF
- ★ Hextet used to refer to a segment of 16 bits or four hexadecimals
- ★ Can be written in either lowercase or uppercase

IPv6 Address Notation ★★★★★ Neso Academy

HOMEWORK

Convert the following numbers into hexadecimal

1. 1078_{10}
2. 1234_8
3. 1234_{10}
4. 10101010100010100_2

HomeworkNeso Academy

HOMEWORK

Which of the following are NOT valid IPv6 addresses?

- A. 225.1.4.2
- B. ::FFFF:10.2.4.1
- C. 2001::1
- D. 2001:0:42:3:ff::1
- E. fe80:2030:31:24
- F. 2001:42:4:0:0:1:34:0
- G. 2003:DEAD:CAFE:cafe:ab33:46:abab:62
- H. 2003:dead:bef:4dad:ab33:46:abab:62

HomeworkNeso Academy

OUTCOMES

Upon the completion of this lecture, the learner will be able to

- ★ Know the rules for representing IPv6 addresses.
- ★ Know IPv6 unicast addresses.
- ★ Know IPv6 address types: Unicast, Multicast and Anycast.

★★★OutcomesNeso Academy

IPv6 ADDRESS – RULES

Rule 1: Omitting Leading 0s

Rule 2: Omitting All 0 Segments

IPv6 Address -RulesNeso Academy

RULE 1

- ★ The first rule to help reduce the notation of IPv6 addresses is any leading 0s (zeros) in any 16-bit section or hexet can be omitted.
- ★ 01AB can be represented as 1AB.
- ★ 09F0 can be represented as 9F0.
- ★ 0A00 can be represented as A00.
- ★ 00AB can be represented as AB.

PREFERRED	2001:0DB8:000A:1000:0000:0000:0000:0100
PREFERRED	2001:0DB8:000A:1000:0000:0000:0000:0100
NO LEADING 0s	2001: DB8: A:1000: 0: 0: 0: 100
COMPRESSED	2001:DB8:A:1000:0:0:0:100

Rule 1★★★★★Neso Academy

RULE 2

- ★ A double colon (:) can replace any single, contiguous string of one or more 16-bit segments (hexets) consisting of all 0's.
- ★ Double colon (:) can only be used once within an address otherwise the address will be ambiguous.
- ★ Known as the compressed format.
- ★ Incorrect address – 2001:0DB8::ABCD::1234.

Rule 2★★★★★Neso Academy

EXAMPLE 1

PREFERRED	2001:0DB8:0000:0000:ABCD:0000:0000:0100
PREFERRED	2001: 0 DB8: 0000 : 0000 :ABCD: 0000 : 0000 : 0100
NO LEADING 0s	2001: DB8: 0: 0:ABCD: 0: 0: 100
COMPRESSED	2001:DB8::ABCD:0:0:100
	OR
COMPRESSED	2001:DB8:0:0:ABCD::100

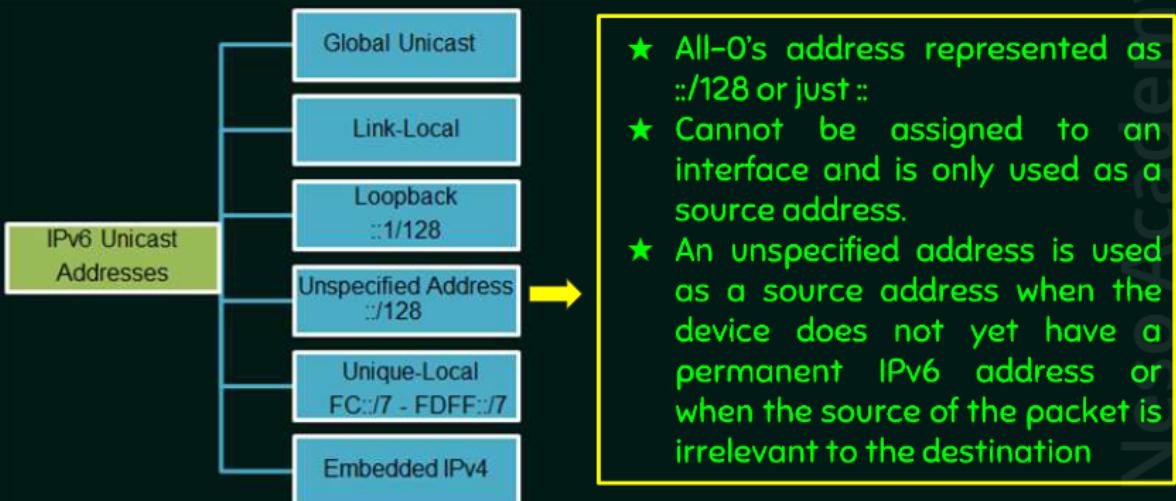
Example 1Neso Academy

EXAMPLE 2

PREFERRED	FE80:0000:0000:0000:0123:4567:89AB:CDEF
PREFERRED	FE80: 0000 : 0000 : 0000 : 0123 : 4567 : 89AB :CDEF
NO LEADING 0s	FE80: 0: 0: 0: 123:4567:89AB:CDEF
COMPRESSED	FE80::123:4567:89AB:CDEF

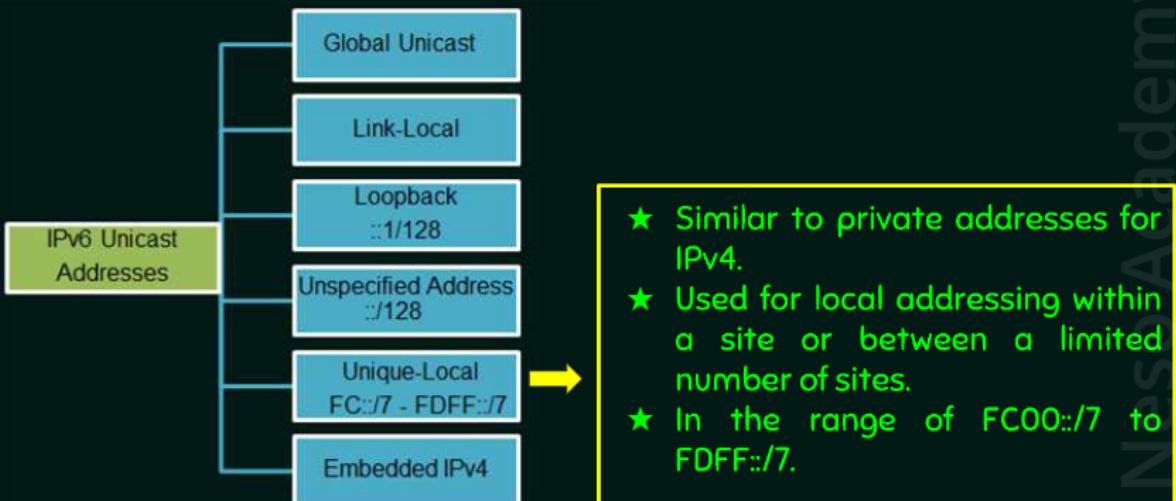
Example 2Neso Academy

IPv6 UNICAST ADDRESSES



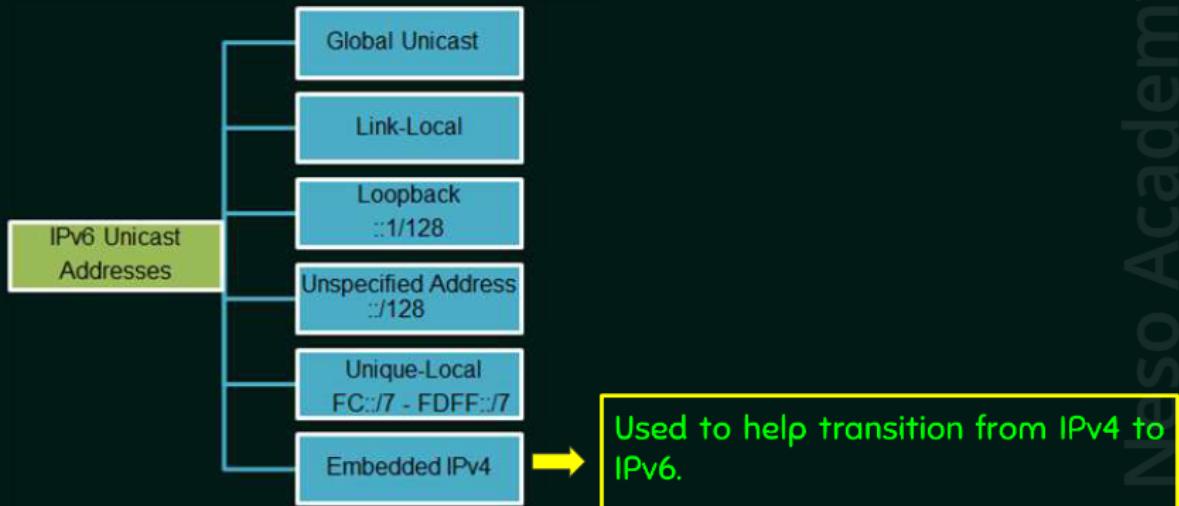
IPv6 Unicast addresses ★★★ Neso Academy

IPv6 UNICAST ADDRESSES



IPv6 Unicast addresses ★★★ Neso Academy

IPv6 UNICAST ADDRESSES



IPv6 Unicast addressesNeso Academy

IPv6 ADDRESS TYPES

There are three types of IPv6 addresses:

1. Unicast
2. Multicast
3. Anycast

Note: IPv6 does not have broadcast addresses.

IPv6 Address TypesNeso Academy

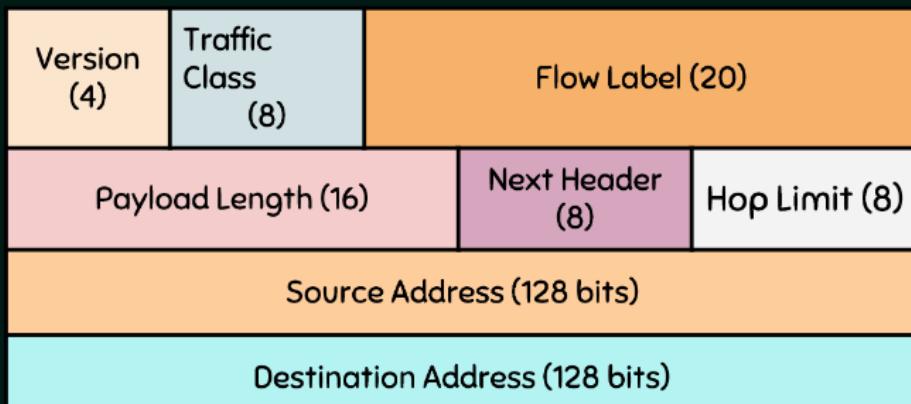
OUTCOMES

Upon the completion of this lecture, the learner will be able to

- ★ Understand the IPv6 header format and its various fields.
- ★ Compare the fields in IPv4 and IPv6 headers.

Outcomes ★★ Neso Academy

IPv6 HEADER FORMAT

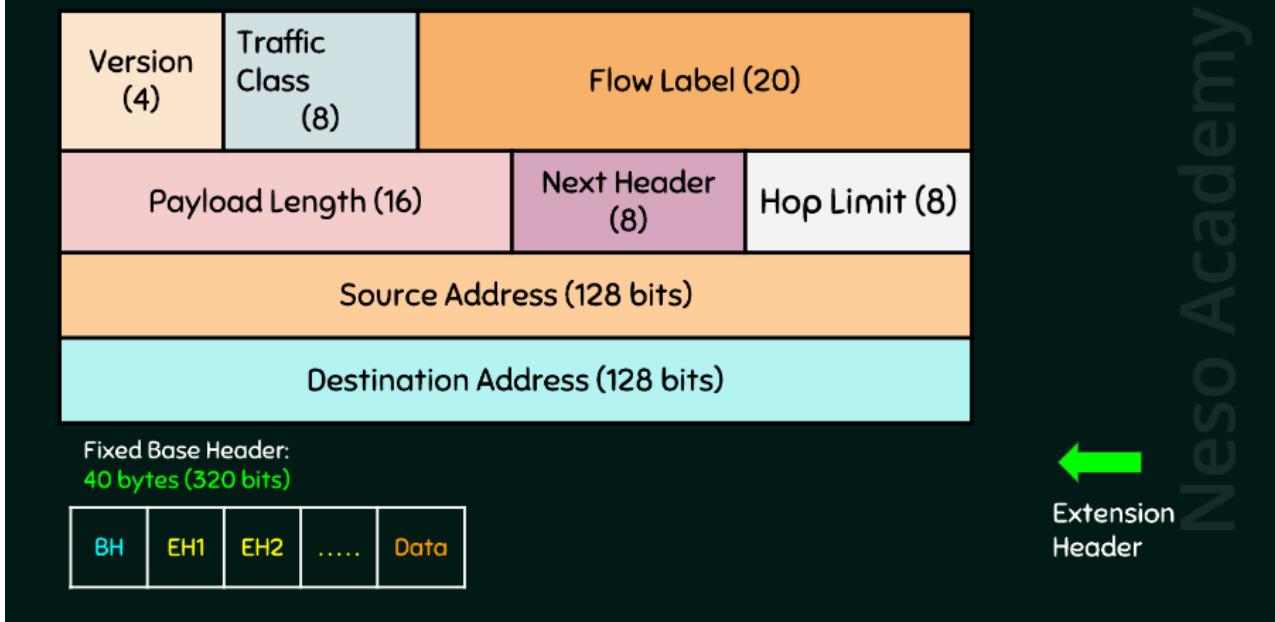


Fixed Base Header:
40 bytes (320 bits)



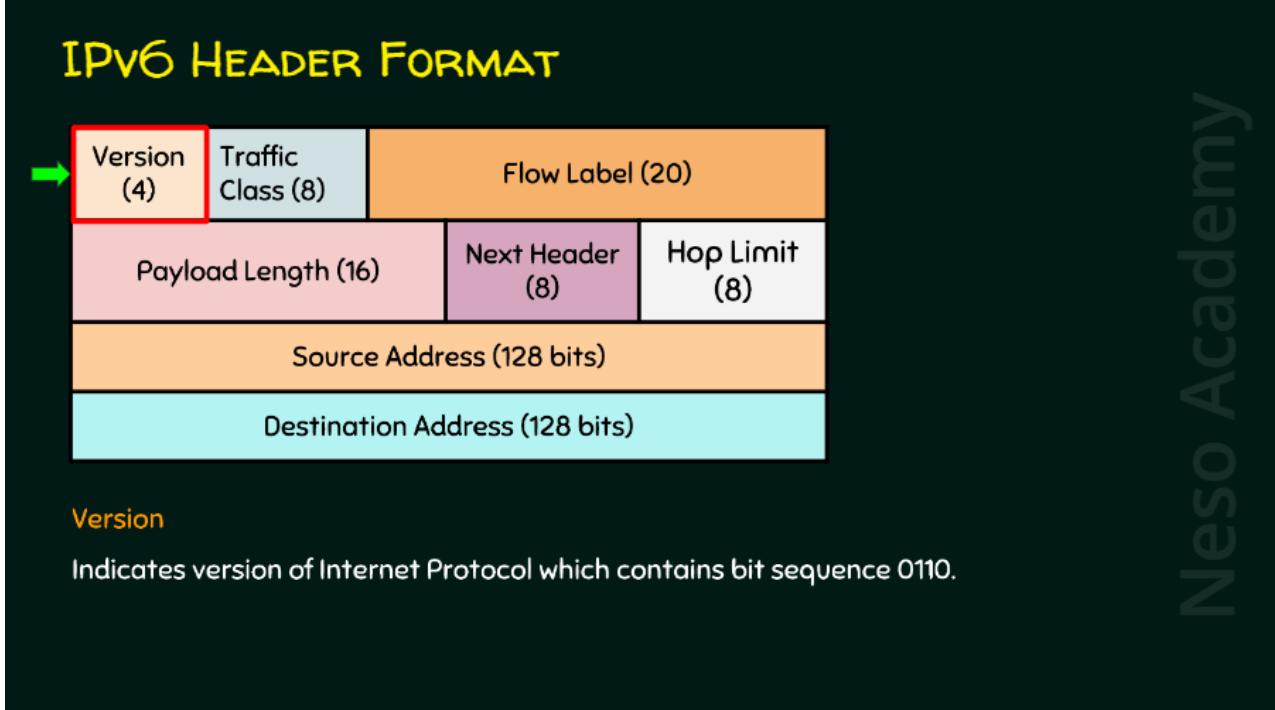
IPv6 Header Format Neso Academy

IPv6 HEADER FORMAT



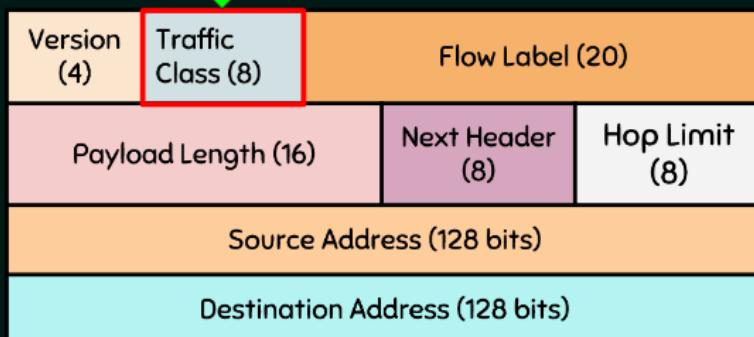
IPv6 Header Format Neso Academy

IPv6 HEADER FORMAT



IPv6 Header Format Neso Academy

IPv6 HEADER FORMAT

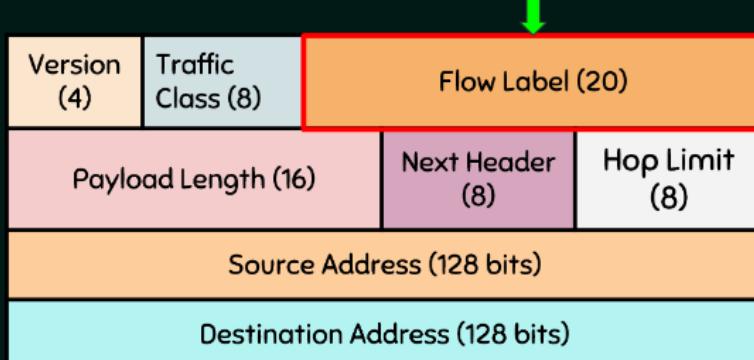


Traffic Class

- ★ The bits of this field hold two values. The six most-significant bits hold the differentiated services field (DS field), which is used to classify packets.
- ★ Currently, all standard DS fields end with a '0' bit. Any DS field that ends with two '1' bits is intended for local or experimental use.
- ★ The remaining two bits are used for Explicit Congestion Notification (ECN).

IPv6 Header Format ★★★ Neso Academy

IPv6 HEADER FORMAT

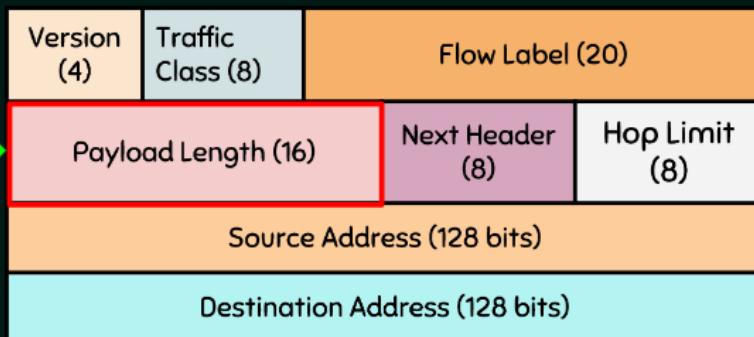


Flow Label

- ★ A high-entropy identifier of a flow of packets between a source and destination.
- ★ A flow is group of packets, e.g., a TCP session or a media stream.
- ★ The special flow label 0 means the packet does not belong to any flow (using this scheme).
- ★ It has further been suggested that the flow label be used to help detect spoofed packets.

IPv6 Header Format ★★★★ Neso Academy

IPv6 HEADER FORMAT

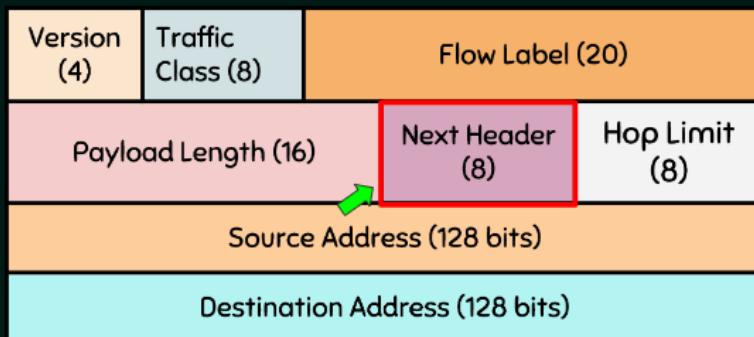


Payment Length

- ★ The size of the payload in octets, including any extension headers.
- ★ The length is set to zero when a Hop-by-Hop extension header carries a Jumbo Payload option.

IPv6 Header Format ★★ Neso Academy

IPv6 HEADER FORMAT

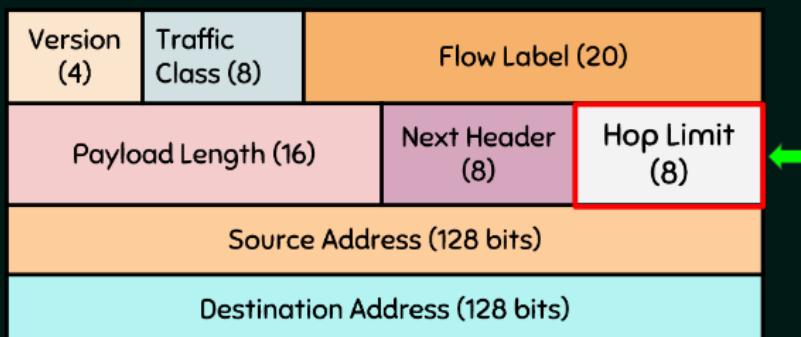


Next Header

- ★ Specifies the type of the next header.
- ★ This field usually specifies the transport layer protocol used by a packet's payload.
- ★ When extension headers are present in the packet this field indicates which extension header follows.

IPv6 Header Format ★★★ Neso Academy

IPv6 HEADER FORMAT

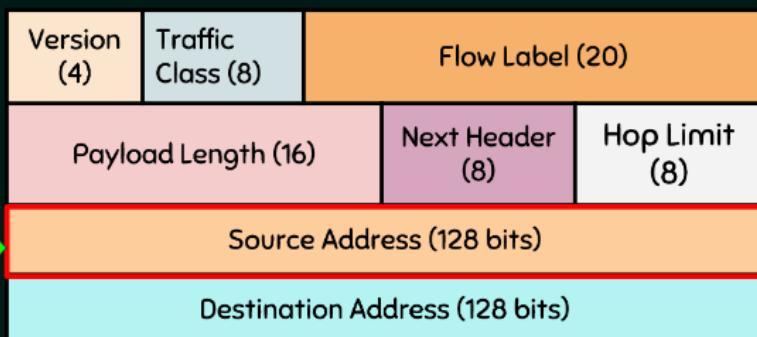


Hop Limit

- ★ Replaces the time to live field in IPv4.
- ★ This value is decremented by one at each forwarding node and the packet is discarded if it becomes 0.
- ★ However, the destination node should process the packet normally even if received with a hop limit of 0.

IPv6 Header Format★★★Neso Academy

IPv6 HEADER FORMAT

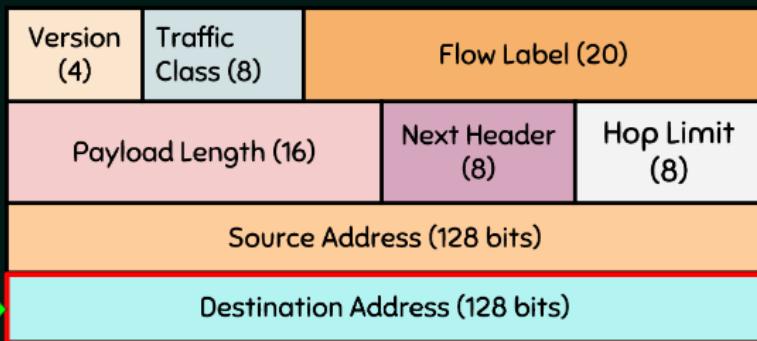


Source Address

- ★ The unicast IPv6 address of the sending node.

IPv6 Header Format★Neso Academy

IPv6 HEADER FORMAT

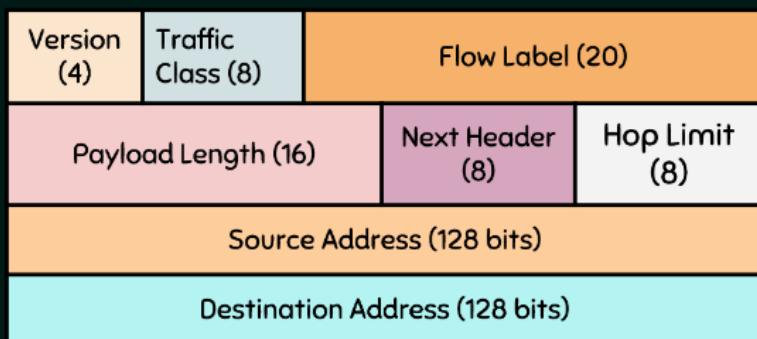


Destination Address

- ★ The IPv6 unicast or multicast address of the destination node(s).

IPv6 Header Format★Neso Academy

IPv6 HEADER FORMAT

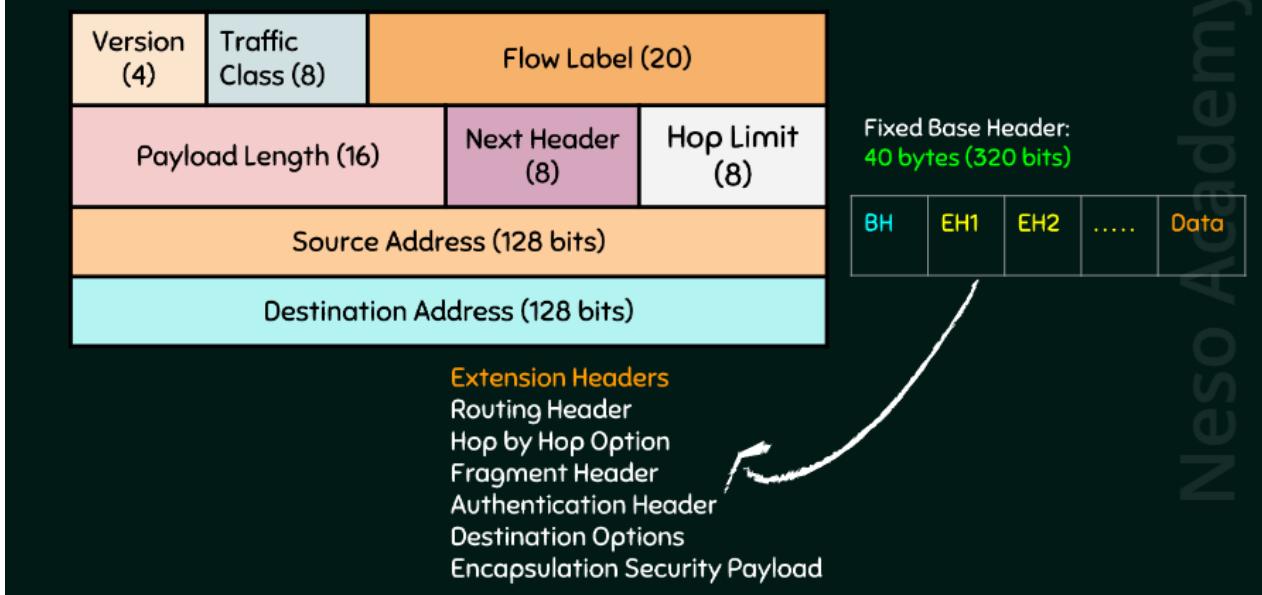


Note

In order to increase performance, and since current link layer technology and transport or application layer protocols are assumed to provide sufficient error detection, the header has no checksum to protect it.

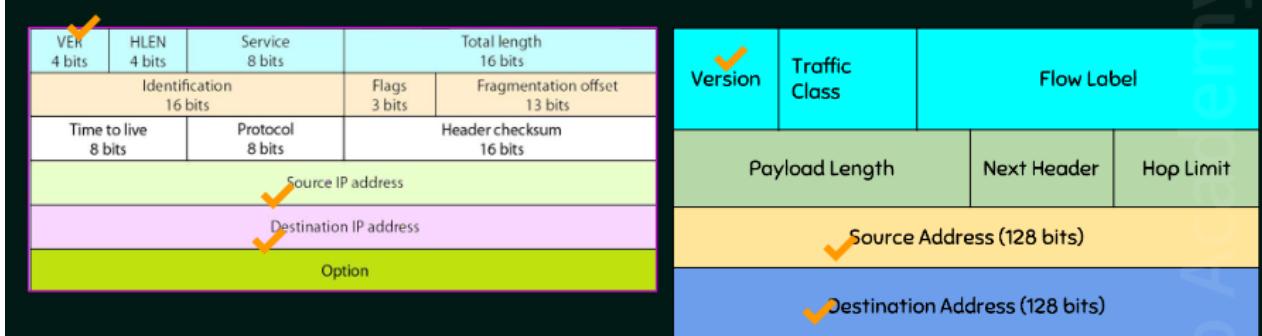
IPv6 Header FormatNeso Academy

IPv6 HEADER FORMAT



IPv6 Header Format Neso Academy

IPv4 AND IPv6



Fields retained from IPv4 to IPv6: Version, Source and Destination IP Address

IPv4 and IPv6 ✓✓✓✓✓✓ Neso Academy

IPv4 AND IPv6

VER 4 bits	HLEN 4 bits	Service 8 bits	Total length 16 bits			
X			Identification 16 bits			
			Flags 3 bits	Fragmentation offset 13 bits		
Time to live 8 bits		Protocol 8 bits	Header checksum 16 bits			
Source IP address						
Destination IP address						
Option						

Version	Traffic Class	Flow Label	
Payload Length		Next Header	Hop Limit
Source Address (128 bits)			
Destination Address (128 bits)			

Fields not retained in IPv6: HLEN, Identification, Flags Fragmentation Offset, Header Checksum, Options and Padding

IPv4 and IPv6 Neso Academy

IPv4 AND IPv6

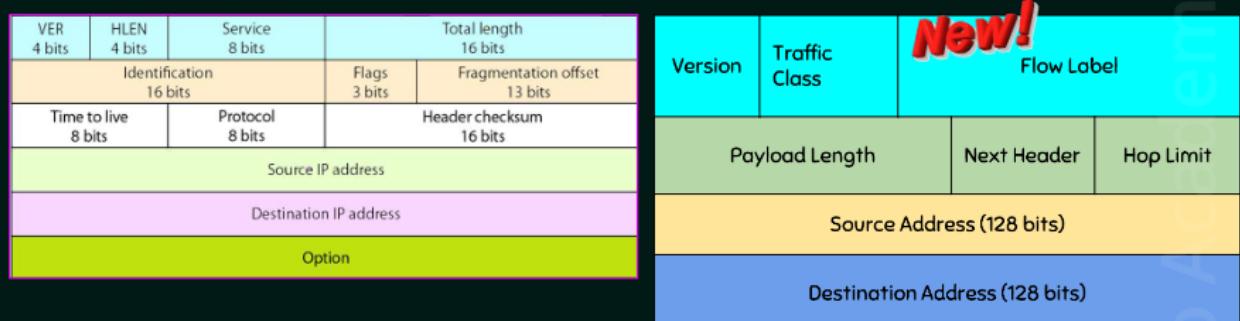
VER 4 bits	HLEN 4 bits	Service 8 bits	Total length 16 bits			
			Identification 16 bits			
			Flags 3 bits	Fragmentation offset 13 bits		
Time to live 8 bits		Protocol 8 bits	Header checksum 16 bits			
Source IP address						
Destination IP address						
Option						

Version	Traffic Class	Flow Label	
Payload Length		Next Header	Hop Limit
Source Address (128 bits)			
Destination Address (128 bits)			

Name and position changed in IPv6: Type of Service, Total Length, Time-to-Live and Protocol

IPv4 and IPv6 Neso Academy

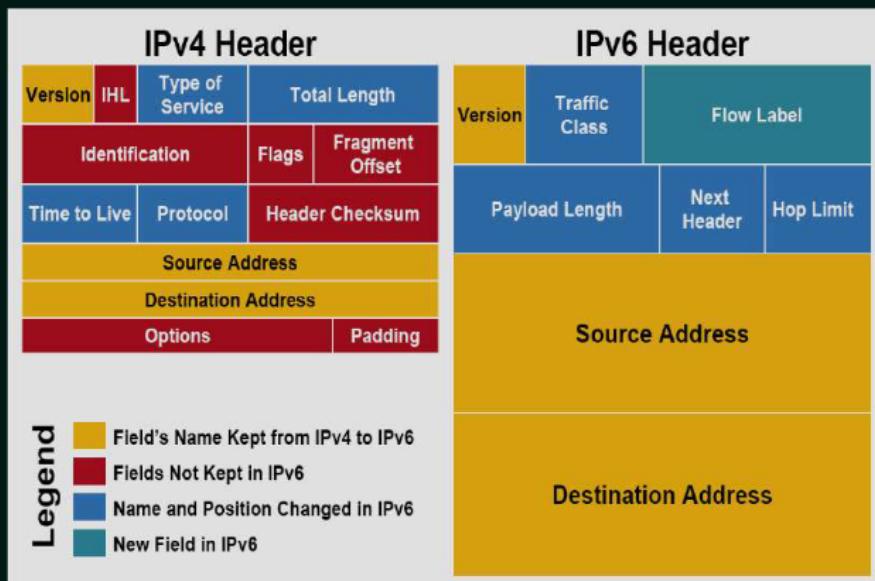
IPv4 AND IPv6



New Field in IPv6: Flow Label

IPv4 and IPv6Neso Academy

IPv4 AND IPv6



IPv4 and IPv6Neso Academy

OUTCOMES

Upon the completion of this session, the learner will be able to

- ★ Know the various address configuration in IPv6.
- ★ Know the structure of an IPv6 Global Unicast Address.
- ★ Understand SLAAC in IPv6.

Outcomes ★★★ Neso Academy

IPv6 ADDRESS CONFIGURATION

- ★ Like IPv4, there are a number of different ways that a host can be addressed in IPv6.
- ★ The two most common in IPv4 are
 - Static addressing and
 - Dynamic addressing configuration via DHCP.
- ★ Why engineers use DHCP?

IPv6 Address Configuration ★★★★★ Neso Academy

IPv6 ADDRESS CONFIGURATION

- ★ IPv6 Address Configuration
 - Static addressing
 - Static addressing with DHCPv6 (stateless)
 - Dynamic addressing via DHCPv6 (Stateful)
 - SLAAC alone, or SLAAC with DHCPv6 (Stateless)
- ★ IPv6 static addressing = IPv4 static addressing.
- ★ Stateless DHCP is then matched up with another mechanism (such as Static addressing or SLAAC) for IPv6 address assignment.

IPv6 Address Configuration ★□□□□★★Neso Academy

STRUCTURE OF AN IPv6 GLOBAL UNICAST ADDRESS

48 bits	16 bits	64 bits
Global Routing Prefix	Subnet ID	Interface ID
A /48 prefix + 16 bit subnet ID = /64 prefix		

- ★ Global Routing Prefix is the prefix or network portion of the address assigned by the provider, such as an ISP, to a customer or site, currently, RIR's assign a /48 global routing prefix to customers.
- ★ 2001:0DB8:ACAD::/48 has a prefix that indicates that the first 48 bits (2001:0DB8:ACAD) is the prefix or network portion.

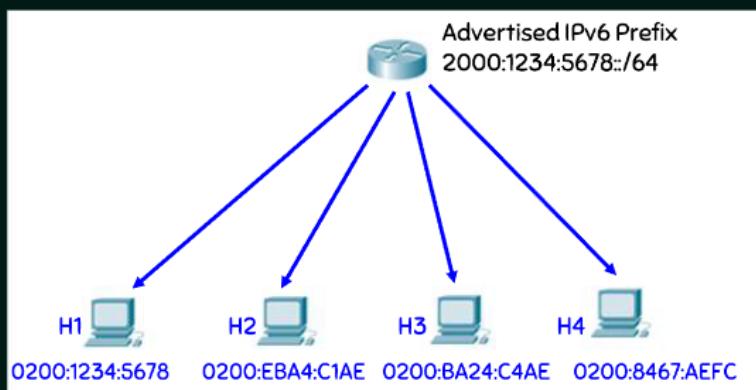
Structure of an IPv6 Global Unicast Address ★★Neso Academy

SLAAC

- ★ SLAAC = Stateless Address Auto-Configuration.
- ★ SLAAC provides the ability to address a host based on a network prefix that is advertised from a local network router via Router Advertisements (RA).
- ★ These messages are sent out periodically by the router and include information including:
 - One or more IPv6 prefixes (Link-local scope)
 - Prefix lifetime information
 - Flag information
 - Default device information (Default router to use and its lifetime)

SLAAC ★★★■■■■■ Neso Academy

SLAAC EXAMPLE



SLAAC Example Neso Academy

OUTCOMES

Upon the completion of this session, the learner will be able to

- ★ Understand EUI-64 Process in IPv6.
- ★ Know the steps to generate the host address using EUI-64 process.

Outcomes ★★ Neso Academy

STRUCTURE OF AN IPv6 GLOBAL UNICAST ADDRESS

48 bits	16 bits	64 bits
Global Routing Prefix	Subnet ID	Interface ID
A /48 prefix + 16 bit subnet ID = /64 prefix		

Structure of an IPv6 Global Unicast Address Neso Academy

EUI-64 PROCESS

- ★ EUI = Extended Unique Identifier.
- ★ It is a method we can use to automatically configure IPv6 host addresses.
- ★ An IPv6 device will use the MAC address of its interface to generate a unique 64-bit interface ID.
- ★ However, a MAC address is 48 bit and the interface ID is 64 bit.

EUI-64 Process ★★★ Neso Academy

EUI-64 STEPS

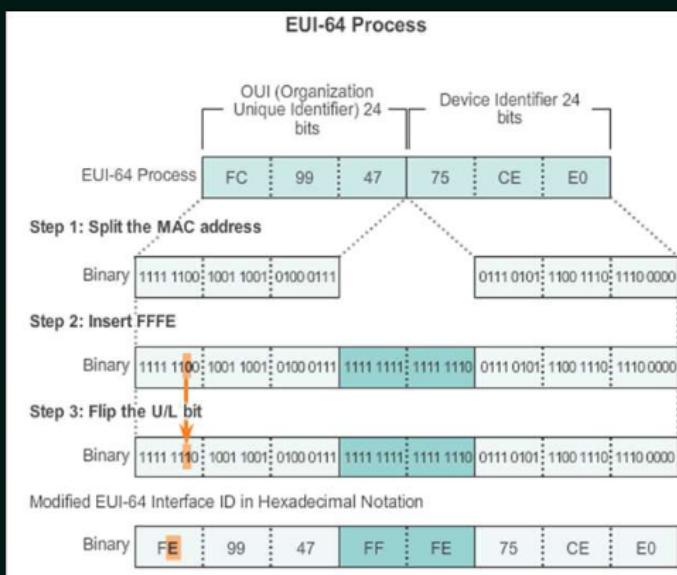
Step 1: Split the MAC address.

Step 2: Insert FFFE.

Step 3: Flip the seventh bit and generate the IPv6 address.

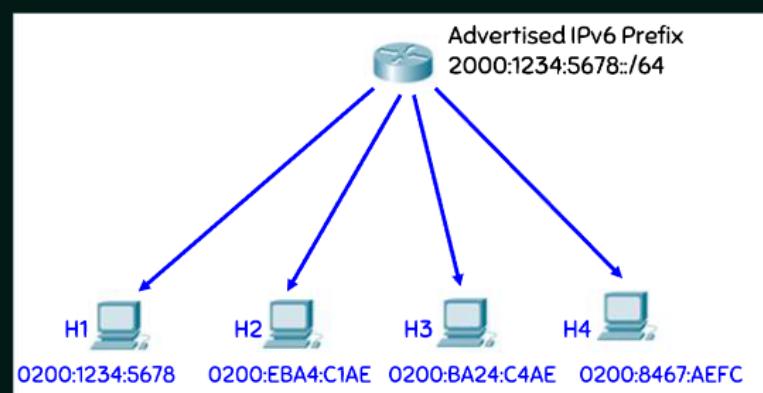
EUI-64 Steps Neso Academy

EUI-64 PROCESS – EXAMPLE



EUI-64 Process -ExampleNeso Academy

EUI-64 PROCESS



H1 – 2000:1234:5678::12FF:FE34:5678

H3 – 2000:1234:5678::BAFF:FE24:C4AE

H2 – 2000:1234:5678::EBFF:FEA4:C1AE

H4 – 2000:1234:5678::84FF:FE67:AEFC

EUI-64 ProcessNeso Academy

HOMEWORK

Use the following values, apply EUI-64 Process and generate the IPv6 address

Advertised IPv6 Prefix = CAFE:23AB:6AFE:: /64

MAC Address = 0EAE.0954.7823

HomeworkNeso Academy



Network Address Translation(NAT)Neso Academy

QUESTION 1

Does IPv6 require NAT?

- Yes
- No

Question 1 Neso Academy

QUESTION 2

Which of the following are disadvantages of using NAT?

1. Translation introduces switching path delays.
2. Conserves legally registered addresses.
3. Causes loss of end-to-end IP traceability.
4. Increases flexibility when connecting to the Internet.
5. Certain applications will not function with NAT enabled.
6. Reduces address overlap occurrence.

- 1, 3 and 5 only
- 3 and 5 only
- 2, 4 and 5 only
- 1 and 5 only

Question 2 Neso Academy

QUESTION 3

Which of the following would be good reasons to run NAT?

1. You need to connect to the Internet and your hosts don't have globally unique IP addresses.
2. You change to a new ISP that requires you to renumber your network.
3. You don't want any hosts connecting to the Internet.
4. You require two intranets with duplicate addresses to merge.

3 only

2 and 4 only

1, 2 and 4 only

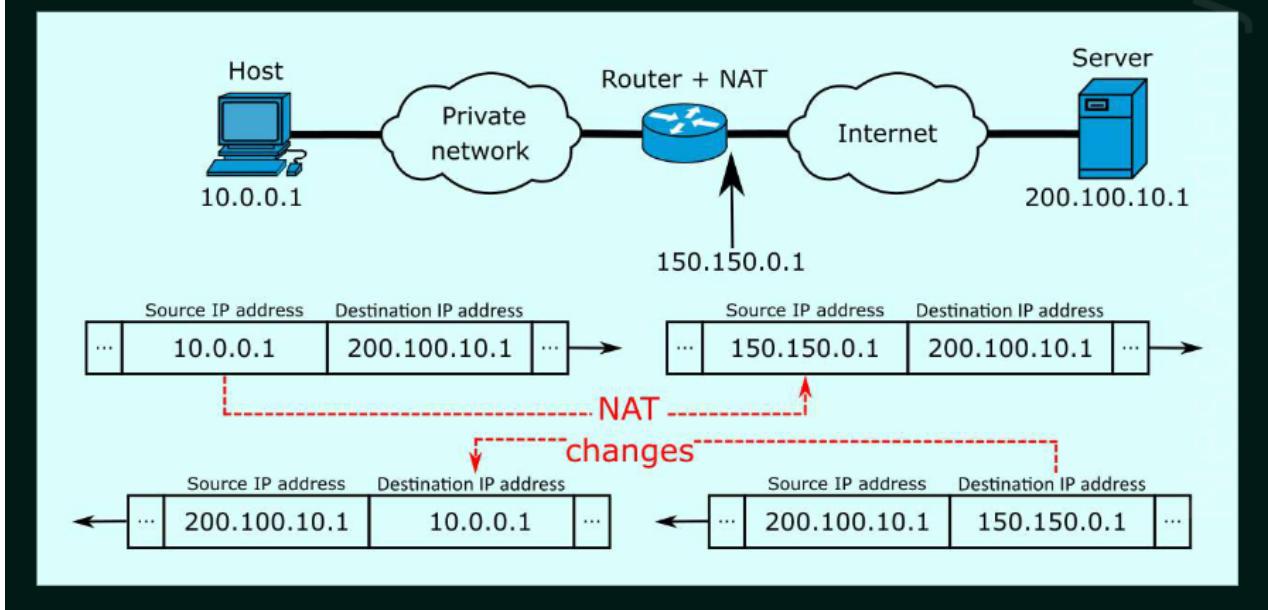
All of the above

Question 3Neso Academy



Network Address TranslationNeso Academy

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TYPES OF NAT

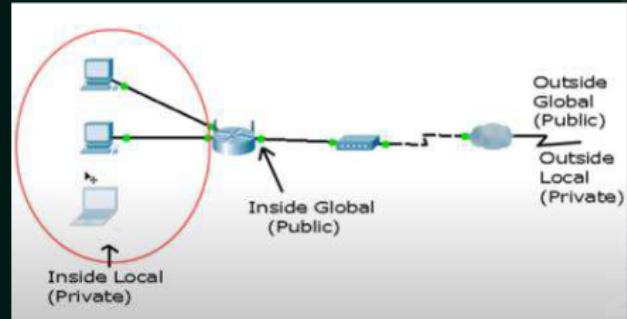
- ★ Static NAT
- ★ Dynamic NAT
- ★ PAT

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Types of NAT ★★★ Neso Academy

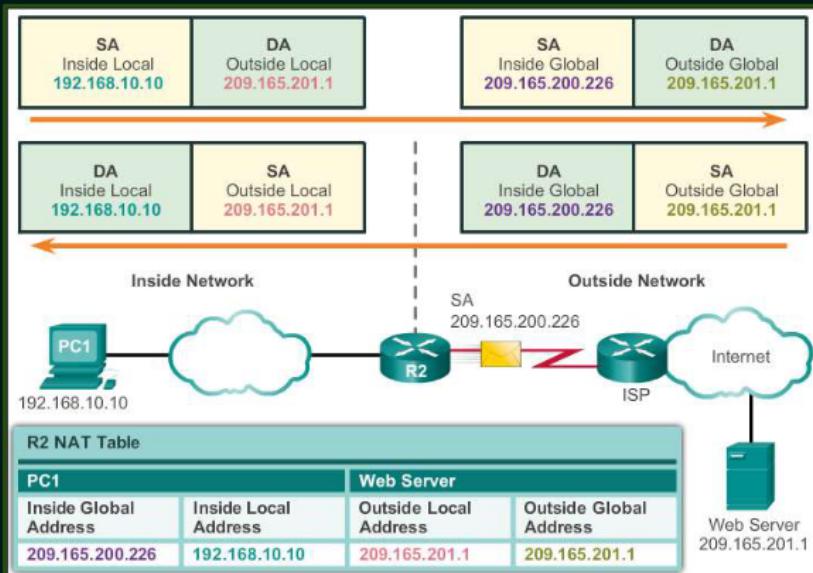
NAT TERMINOLOGIES

- ★ Inside network is the set of devices using private addresses.
- ★ Outside network refers to all other networks.
- ★ NAT includes four types of addresses:
 - Inside local address
 - Inside global address
 - Outside local address
 - Outside global address



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NAT TERMINOLOGIES



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QUESTION 1

What is the size of IPv6 address?

- 32 bits
- 32 bytes
- 128 bits ✓
- 128 bytes

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QUESTION 2

EUI-64 process is a method we can use to automatically configure IPv6 host addresses.

- True ✓
- False

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QUESTION 3

The MAC address of host is 0200:1234:5678 and the initial prefix learned by the router's RA message is 2000:1234:5678::/64. What is the resulting IPv6 host address?

Solution

MAC Address: 0200:1234:5678

Step 1: 0200:12 34:5678

Step 2: 0200:12FF:FE34:5678

0000001000000000:12FF:FE34:5678

Step 3: 0000000000000000:12FF:FE34:5678

2000:1234:5678::0000:12FF:FE34:5678

2000:1234:5678::12FF:FE34:5678

Question 3 Neso Academy

QUESTION 4

Stateful DHCP does not track what information is given out to clients and does not give out IPv6 addresses.

- True
- False ✓

Question 4 ✓ Neso Academy