

# **Table of Contents**

- ► IP Terminology
- ► The Hierarchical IP Addressing Scheme
- ▶ IPv4 Address Types
- Network Address Translation (NAT)
- ► Internet Protocol Version 6 (IPv6)



1

# **IP Terminology**



# **IP Terminology**



- Octet Same as byte, made up of 8 bits
- Network Address This is the designation used in routing to send packets to a remote network—for example, 10.0.0.0, 172.16.0.0, and 192.168.10.0.
- **Host Address** A logical address used to define a single host
- Broadcast Address Used by applications and hosts to send information to all hosts on a network. For example
   255.255.255, which designates all networks and all hosts

2

# The Hierarchical IP Addressing Scheme



# The Hierarchical IP Addressing Scheme



- IP address consists of 32 bits or 4 bytes or 4 octets
- Represented as:
  - o 54.164.151.235 or
  - o 00110110.10100100.10010111.11101011 or
  - o 66.A4.97.EB
- 32-bit IP address is structured (or hierarchical) address to make routing possible
- If IP address was flat (or non hierarchical) routing would be impossible



- The network address (or network number) uniquely identifies each network
- Every machine on the same network shares that network address as part of its IP address
- For example:

IP Address: 154.101. 51.235 Host address

Network address: Every device in this

network starts with these numbers

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# The Hierarchical IP Addressing Scheme

Network addresses are divided into 5 classes:

	Octet 1					Octet 2	Octet 3	Octet 4	
Class A	0		Ne	etwo	rk ID		Host ID		
Class B	1	0			Netwo	rk ID	Host ID		
Class C	1	1	0			Network ID		Host ID	
Class D	1	1	1	0		Multica	st Address		
Class E	1	1	1	1		Re	served		

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#### **Class A Addresses**

# network host host

- Class A Network address is 1-byte long, first bit is always 0
- Maximum  $2^7$  = 128 Class A networks can be created
- Maximum 2<sup>24</sup> = 16,777,214 hosts (excluding 2 reserved addresses)
- First bit is always 0 then
   00000000 = 0
  - **0**1111111 = 127
- The addresses 00000000 and 01111111 are reserved for default route and troubleshooting respectively
- So Class A network addresses start with 1-126

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## The Hierarchical IP Addressing Scheme



#### **Class A Addresses**

Address	Function				
Network address of all 0s (0.X.X.X)	Means "this network or segment."				
Network address of all 1s (127.X.X.X)	Means "all networks."				
127.0.0.1	Reserved for loopback tests. Designates the local host and allows that host to send a test packet to itself without generating network traffic.				
Host address of all 0s (X.0.0.0)	Means "network address" or any host on the specified network.				
Host address of all 1s (X.255.255.255)	Means "all hosts" on the specified network				
Entire IP address set to all 0s (0.0.0.0)	Any host on any network				
Entire IP address set to all 1s (255.255.255.255)	Broadcast to all hosts on the current network				

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10



#### **Class B Addresses**

network network host host

- Class B Network Address is 2-byte long, first 2 bits are always 10
- Maximum 2<sup>14</sup> = 16,384 Class B networks can be created
- Maximum 2<sup>16</sup> = 65,534 hosts (excluding 2 reserved addresses)
- First 2 bits are always 10 then

10000000 = 128 10111111 = 191

Class B Network Addresses start with 128-191



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# The Hierarchical IP Addressing Scheme



#### Class C Addresses

network network host

- Class C Network Address is 3-byte long, first 3 bits are always 110
- Maximum 2<sup>21</sup> = 2,097,152 Class C networks can be created
- Maximum 2<sup>8</sup> = 254 hosts (excluding 2 reserved addresses)
- First 3 bits are always 110 then

11000000 = 192

**110**11111 = 223

Class C Network Addresses start with 192-223



#### **Class D Addresses**

- Not assigned to devices on a network
- Used for special-purpose, multicast applications (such as videoand audio-streaming applications)
- Need to be registered with IANA to be used globally
- First 4 bits are always 1110 then

```
11100000 = 224
11101111 = 239
```

• Class D Network Addresses start with 224-239



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# The Hierarchical IP Addressing Scheme



#### **Class E Addresses**

- No defined use
- Reserved for usage and testing by IANA and the Internet Research Task Force (IRTF)
- Need to be registered with IANA to be used globally
- First 4 bits are always 1111 then

```
11110000 = 240
11111111 = 255
```

Class E Network Addresses start with 240-255



IP Address Classes:

Address Class	1st Octet Range	1st Octet Bits	Network & Host Parts	# of Possible Networks # of Hosts per Network
A	1-126	00000000 - <mark>0</mark> 1111111	N.H.H.H	128 nets (2 <sup>7</sup> ) 16,777,214 hosts per net (2 <sup>24</sup> )-2
В	128-191	10000000 - 10111111	N.N.H.H	16,384 nets (2 <sup>14</sup> ) 65,534 hosts per net (2 <sup>16</sup> )-2
С	192-223	11000000 - 11011111	N.N.N.H	2,097,150 nets (2 <sup>21</sup> ) 254 hosts per net (2 <sup>8</sup> )-2



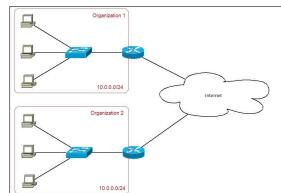
11

# The Hierarchical IP Addressing Scheme



#### **Private IP Addresses (RFC 1918)**

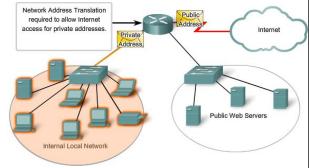
Every host on every network should have a routable IP address. But if every host on every network in the world was required to have an unique IP address, we would have run out of IP addresses!





#### Private IP Addresses (RFC 1918)

- The IANA reserved the following IP address blocks for use as private IP addresses:
  - o Class A: 10.0.0.0 to 10.255.255.255
  - o Class B: 172.16.0.0 to 172.31.255.255
  - o Class C: 192.168.0.0 to 192.168.255.255



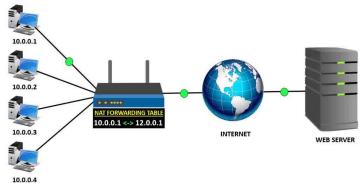


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### Introduction to NAT



- NAT is a process in which one or more local IP addresses are translated into one or more global IP address and vice versa to provide Internet access to the local hosts
- NAT allows multiple devices to access the Internet through a single public address



### Introduction to NAT



- Advantages:
  - Hides internal structure of the network from the outsider and thus increases network security
  - Eliminates address renumbering when a network evolves
  - Allows unlimited private IP address range
- Disadvantages:
  - Changes the IP addresses, thus troubleshooting becomes more complex
  - Translation results in switching path delays
  - o Certain applications will not function while NAT is enabled
  - Complicates tunneling protocols such as IPsec

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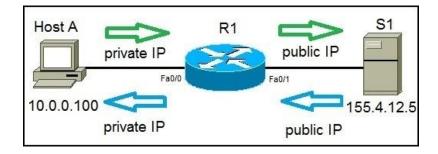
4

### Introduction to NAT



#### Types of NAT:

- Static NAT (SNAT):
  - One-to-one mapping (A single private IP with a single global IP)
  - Each device needs a public IP address
  - Generally used for web hosting



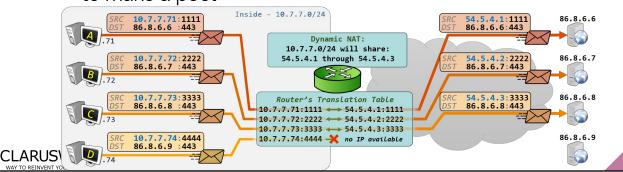


### Introduction to NAT



#### Types of NAT:

- Dynamic NAT (DNAT):
  - Public IP is picked from a pool of IP addresses
  - If no IP is left, data packet is dropped by the NAT
  - Very costly as many global IP addresses have to be bought to make a pool

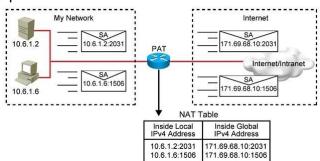


### Introduction to NAT



#### Types of NAT:

- Overloading or Port Address Translation (PAT):
  - Most popular type of NAT
  - Port numbers are used to distinguish the traffic
  - Cost-effective as lots of users can be connected by using only one public IP address





#### **APIPA**

- In a network, Dynamic Host Configuration Protocol (DHCP) server assigns IP addresses to all the hosts connected to the network
- If DHCP server isn't available, Windows provides Automatic Private IP Addressing (APIPA) service to configure the IP addresses for the hosts
- 169.254.0.1 169.254.255.254 reserved for **APIPA**



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# **IPv4 Address Types**



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## IPv4 Address Types



#### **Layer 2 Broadcasts**

- Layer 2 broadcast traffic stays within a local area network (LAN) boundary; known as the broadcast domain
- A MAC address of FF:FF:FF:FF:FF is used for broadcast



### **IPv4 Address Types**



#### **Layer 3 Broadcasts**

- Layer 3 broadcast traffic is sent to all devices in a network
- A network address of X.255.255.255 is used for broadcast
- Address Resolution Protocol (ARP) uses broadcasting to map MAC addresses to IP addresses
- **Dynamic Host Configuration Protocol (DHCP)** uses broadcasting to dynamically assign IP addresses to hosts

# **IPv4** Address Types



#### **Unicast Address**

- Identifies a unique node on a network
- Packets addressed to a unicast address are delivered to the node identified by the address
- Unicast address has the MAC address of the destination device

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# IPv4 Address Types



#### **Multicast Address**

- Represent a group of devices in a LAN
- Multicast frames have a value of 1 in the least-significant bit of the first octet of the destination address
- Multicast addresses range from 224.0.0.0 to 239.255.255.255
   (Class D)



4

# Internet Protocol Version 6 (IPv6)



### Internet Protocol Version 6 (IPv6)



Why do we need IPv6?

ΙP	<b>v</b> 4	A	dd	re	SS	Sp	ac	e (	Co	ns	ur	np	tic	n
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
			20		22	23	24		26	27	28	29	30	
33	34	35	36		38	39	40	41	42	43	44	45	46	
49	50		52	53	54		56		58	59	60	61		
	66		68		70		72		74	75	76		78	79
	82	83	84	85	86		88	89	90		92		94	95
	98	99	100		102	103	104		106		108			
113	114						120	121	122		124	125	126	127
129	130	131	132			135	136		138					
145		147	148	149			152		154	155			158	
	162		164	165		167			170		172	173	174	
177	178	179	180				184	185	186		188			
	194		196	197	198		200				204			207
209	210		212	213			216	217	218		220	221	222	223
225	226	227	228	229	230		232	233	234	235	236	237	238	239
241	242	243	244	245	246	247	248	249	250		252		254	
	1 17 33 49 65 81 97 113 129 145 161 177 193 209	1 2 17 18 33 34 49 50 65 66 81 82 97 98 113 114 129 130 145 146 161 162 177 178 193 194 209 210	1 2 3 17 18 19 33 34 35 49 50 51 65 66 67 81 82 83 97 98 99 113 114 115 129 130 131 145 146 147 161 162 163 177 178 179 193 194 195 209 210 211	1 2 3 4 17 18 19 20 33 34 35 36 49 50 51 52 65 66 67 68 81 82 83 84 97 98 99 100 113 114 115 116 129 130 131 132 145 146 147 148 161 162 163 164 177 178 179 180 193 194 195 196 209 210 211 212	1 2 3 4 5 17 18 19 20 21 33 34 35 36 37 49 50 51 52 53 65 66 67 68 69 81 82 83 84 85 97 98 99 100 101 113 114 115 116 117 129 130 131 132 133 145 146 147 148 149 145 146 165 177 178 179 180 181 193 194 195 196 197 209 210 211 212 213	1	1 2 3 4 5 6 7 17 18 19 20 21 22 23 33 34 35 36 37 38 39 49 50 51 52 53 54 55 65 66 67 68 69 70 71 81 82 83 84 85 86 87 97 98 99 100 101 102 103 113 114 115 116 117 118 119 129 130 131 132 133 134 135 145 146 147 148 149 150 151 161 162 163 164 165 166 167 177 178 179 180 181 182 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  52         53         54         55         56         57         58         59         60         61         62           65         66         67         68         69         70         71         72         73         74         75         76         77         78           81         82         83         84         85         86         87         88         89         90         91         92         93         94           97         98         99         100         101         102         103         104         105         106         107         108         109         110           113         114         115         116         117         118         119         120         121         122         123





• IPv4 — 4,294,467,295 IP addresses

Class A → 16,777,216 Class B → 65,535 Class C → 256

Large companies (Apple, IBM, Microsoft, etc.) allocated one or more Class A addresses



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### Internet Protocol Version 6 (IPv6)



• IPv6 is 128-bit long:

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

Enough IP addresses for the entire galaxy!

- IPv6 is 128-bit long:
  - 340 undecillion
  - 282 decillion
  - 366 nonillion
  - 920 octillion
  - 938 septillion
  - 463 sextillion
  - 463 quintillion
  - 374 quadrillion
  - 607 trillion
  - 431 billion
  - 768 million
  - 211 thousand
  - 456





3

### Internet Protocol Version 6 (IPv6)

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- More Efficient Routing
- More Efficient Packet Processing
- Directed Data Flows No broadcasts!
- Simplified Network Configuration
- Support For New Services No need for NAT!
- Security





• IP Address representation:

**Octet** 

IPv4 — 51.151.64 242

IPv6 — 2041:1234:140F:1122:AB91:564F:875B:131B

On browsers:

Hexadectet or hextet

IPv4: http://51.151.64.242/index.html

IPv6:

http://[2041:1234:140F:1122:AB91:564F:875B:131B]/index.html

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### Internet Protocol Version 6 (IPv6)



• Shortening IPv6 Addresses:

Original : 2041:0000:140F:0000:0000:0000:875B:131B



Short : 2041:0000:140F::875B:131B

Original : 2001:0000:0000:0012:0000:0000:1234:56ab



Wrong! : 2001::0012::1234:56AB



You can remove zeros only once!



Shortening IPv6 Addresses:

Original : 2041:0000:140F:0000:0000:0000:875B:131B

Short : 2041:0:140F::875B:131B

Original : 2001:0001:0002:0003:0004:0005:0006:0007

Short : 2001:1:2:3:4:5:6:7

Rules:

o An entire string of zeros can be removed, you can only do this once

o 4 zeros can be removed, leaving only a single zero

Leading zeros can be removed

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### Internet Protocol Version 6 (IPv6)



IPv6 Address Types:

- Unicast Address
  - Link Local Address: Only valid in local networks. Starts with FE80::/10
  - Global Unicast Address: Worldwide unique address. Starts with 2000 to 3FFF
- Multicast address Same as IPv4. Starts with FF00::/8
- Anycast Address Similar to broadcast but instead of sending to all nodes, sends to the closest nodes to sender.

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### IPv6 Special Addresses:

Address	Meaning
0:0:0:0:0:0:0:0	Equals ::. The equivalent of IPv4's 0.0.0.0 and is typically the source address of a host before the host receives an IP address when you're using DHCP-driven stateful configuration
0:0:0:0:0:0:0:1	Equals ::1. The equivalent of 127.0.0.1 in IPv4.
2000::/3	The global unicast address range allocated for Internet access.
FC00::/7	The unique local unicast range.
FE80::/10	The link-local unicast range.
FF00::/8	The multicast range.
3FFF:FFFF::/32	Reserved for examples and documentation.
2001:0DB8::/32	Also reserved for examples and documentation.
2002::/16	Used with 6to4 tunneling, which is an IPv4-to-IPv6 transition system.
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### Internet Protocol Version 6 (IPv6)

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Stateless Autoconfiguration (EUI-64):

#### 48-bit MAC address

	00	00	42	20	19	45		
	00000000	00001100	01000010	00101000	01111001 0100010			
		ufacturer ID rse 7-th bit			Move device ID at the end			
00000010	00001100	01000010	11111111	11111110	00101000	01111001	01000101	
02	0C	42	FF	FE	28	79	45	

64-bit EUI-64 address





Advantages of EUI-64:

- Doesn't require support of a DHCP server
- Allows hot plugging of network devices
- Suitable for applications requiring secure connection without additional intermediaries in the form of a proxy or a DHCP server
- Cost effective
- Suitable for wireless networks

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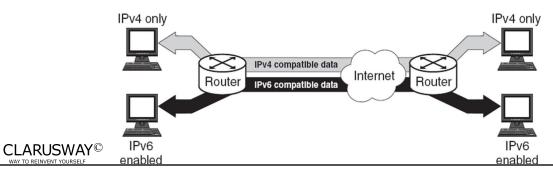
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### Internet Protocol Version 6 (IPv6)



Migrating to IPv6:

- Dual Stacking
  - Most common and easiest migration
  - Allows devices to communicate either IPv4 or IPv6
  - Lets you upgrade your devices to IPv6 one at a time



42

