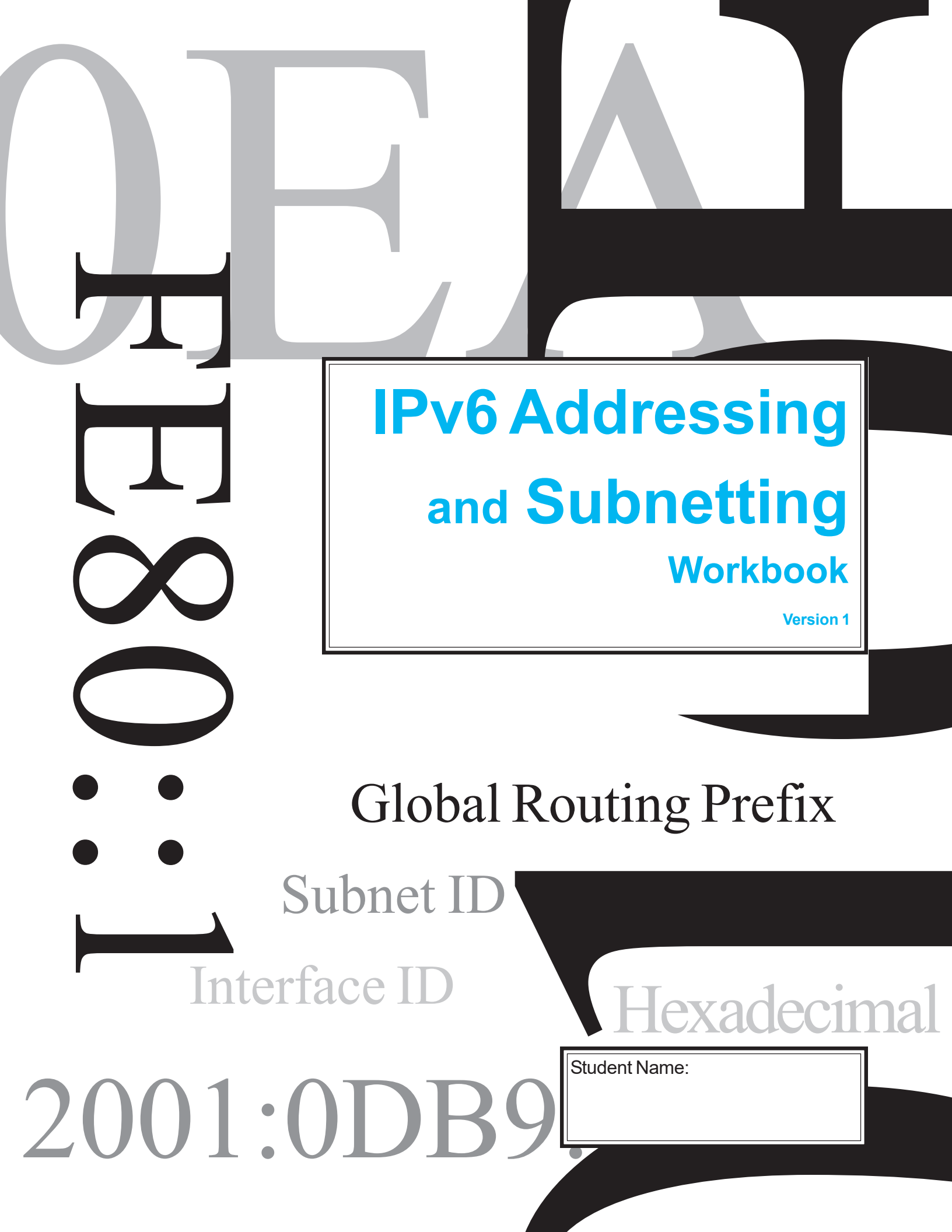
IPv6 Addressing
and Subnetting
Workbook
Version 1
FE80::1
Global Routing Prefix
Subnet ID
Interface ID
Hexadecimal
2001:0DB9:
Student Name:

Types of IPv6 Addresses

Unspecified, Loopback, Embedded IPv4

Unspecified address is an all 0 address and cannot be assigned to an interface. It would be typed as ::. This is only used as a source address to indicate the absence of an actual address.

Loopback Address is all 0's except for the last bit, which is 1. It would be typed as ::1. It operates the same as the IPv4 127.0.0.1 loopback address.

IPv4 Embedded addresses are IPv6 addresses with an IPv4 address embedded in the low-order 32 bits. They are used to transition networks from IPv4 to IPv6.

Address Range:
0000:0000:0000:0000:0000:0000:0000:0000/8 to 00FF:FFFF:FFFF:FFFF:FFFF:FFFF:FFFF:FFFF/8

Global Unicast

Global Unicast addresses are used to uniquely identify a specific interface on a host and can be used as a public address on the internet.

Address Range:
2000:0000:0000:0000:0000:0000:0000:0000/3 to 3FFF:FFFF:FFFF:FFFF:FFFF:FFFF:FFFF:FFFF/3

Unique local Unicast

Unique local Unicast addresses are roughly the same as IPv4 private addresses.

Address Range:
FC00:0000:0000:0000:0000:0000:0000:0000/7 to FDFF:FFFF:FFFF:FFFF:FFFF:FFFF:FFFF:FFFF/7

Link-local Unicast

Link-local addresses are unicast addresses that are limited to a point to point connection within a local network. Routers will not forward packets with a link-local address.

Address Range:
FE80:0000:0000:0000:0000:0000:0000:0000/10 to FEBF:FFFF:FFFF:FFFF:FFFF:FFFF:FFFF:FFFF/10

Multicast

Multicast addresses are used to send a single packet to multiple destinations simultaneously.

Address Range:
FF00:0000:0000:0000:0000:0000:0000:0000/8 to FFFF:FFFF:FFFF:FFFF:FFFF:FFFF:FFFF:FFFF/8

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A Brief History of TCP/IP Versions

TCP version 1 through TCP version 3 were developed as test versions and not widely used. Contrary to popular belief there was never an IPv1, IPv2, or IPv3. The version numbers were kept intact to avoid confusion when the TCP protocol was split into TCP and IP.

1973 - TCP version 1 was developed and documented in RFC 675.
At this time IP was part of TCP.

1977 - TCP version 2 was developed and documented in March.
In August of 1977 it was decided that the TCP protocol was going in the wrong direction.

1978 - TCP and IP were split into two separate protocols.
Both TCP and IP were part of version 3.

1980 - Early development of IPv4 defined in RFC 760.

1981 - The current version of IPv4 is defined in RFC 791, 792 and 793.
It was the first widely used version of the Internet Protocol.

1983 - On January 1, 1983, TCP/IP protocols became the only approved protocol on the ARPANET, replacing the earlier NCP protocol. This was known as flag day.

1984 - The number of hosts on the internet breaks 1000.

1987 - Hosts on the internet exceeds 10,000.

1989 - Host accessing the internet surpasses 100,000.

1990 - IPv5 relates to an experimental TCP/IP protocol called the Internet Stream Protocol, Version 2, originally defined in RFC 1190. This protocol was a peer of IPv4 and was designed to work with voice conversations and conferences with delay and bandwidth guarantees. These packets were assigned IP version 5 to differentiate them from “normal” IPv4 packets. This protocol was never introduced to the public, and was always considered experimental. To be sure there would be no confusion, version 5 was skipped over in favor of version 6.

1992 - The number of hosts on the internet breaks 1,000,000.

1995 - IPv6, introduced as IP Next Generation, was presented in RFC 1883.

1997 - The number of hosts using the internet exceeds 19,000,000.

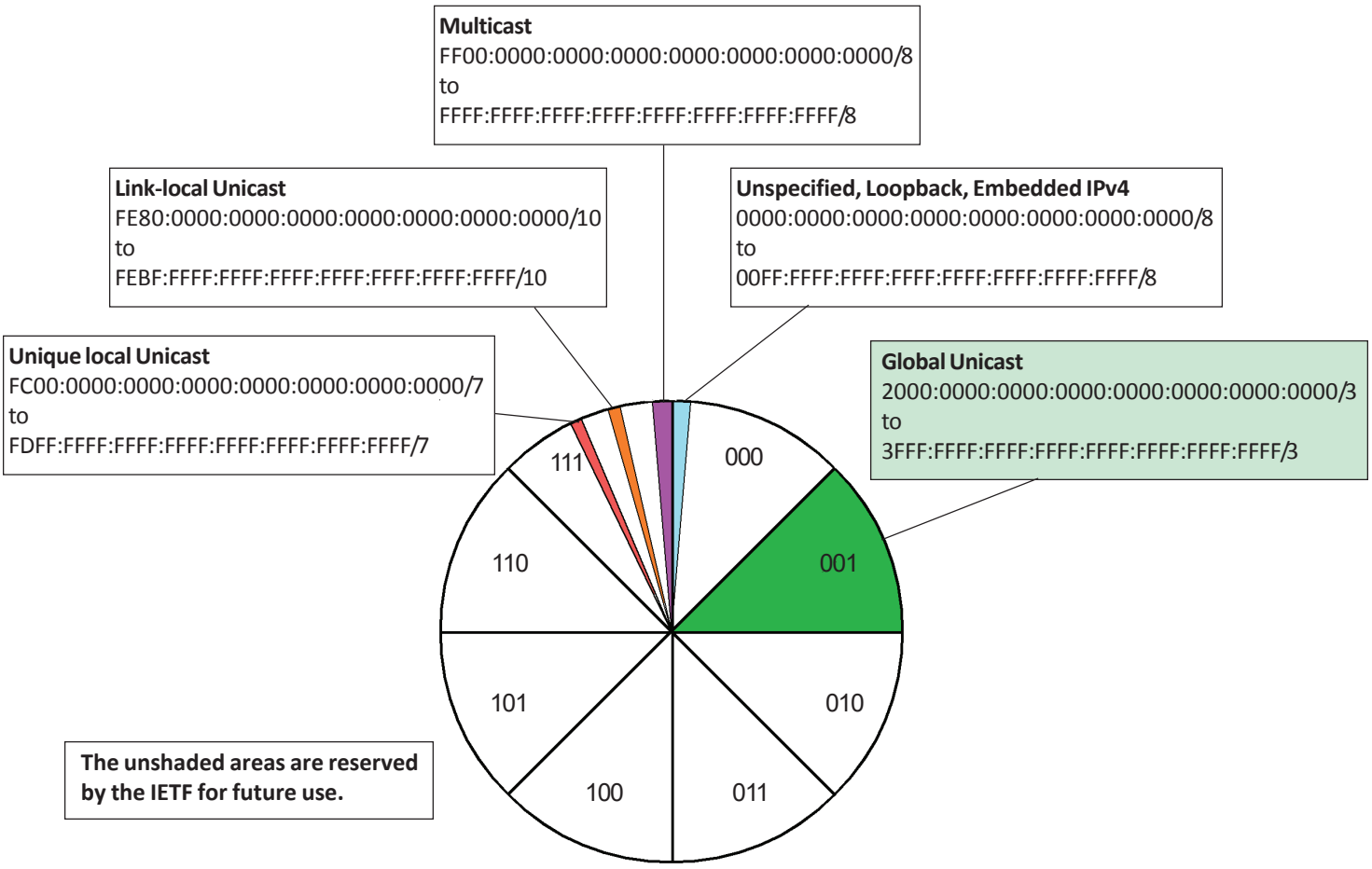
1998 - The more fully developed IPv6 obsoletes RFC 1883 with the updated RFC 2460.

IPv4 has been well established for years. IPv6 is still in flux as it undergoes growing pains with changes and adjustments to the rules as it is being implemented.

IPv6

There are 340,282,366,920,938,463,463,374,607,431,768,211,456 possible IPv6 addresses.

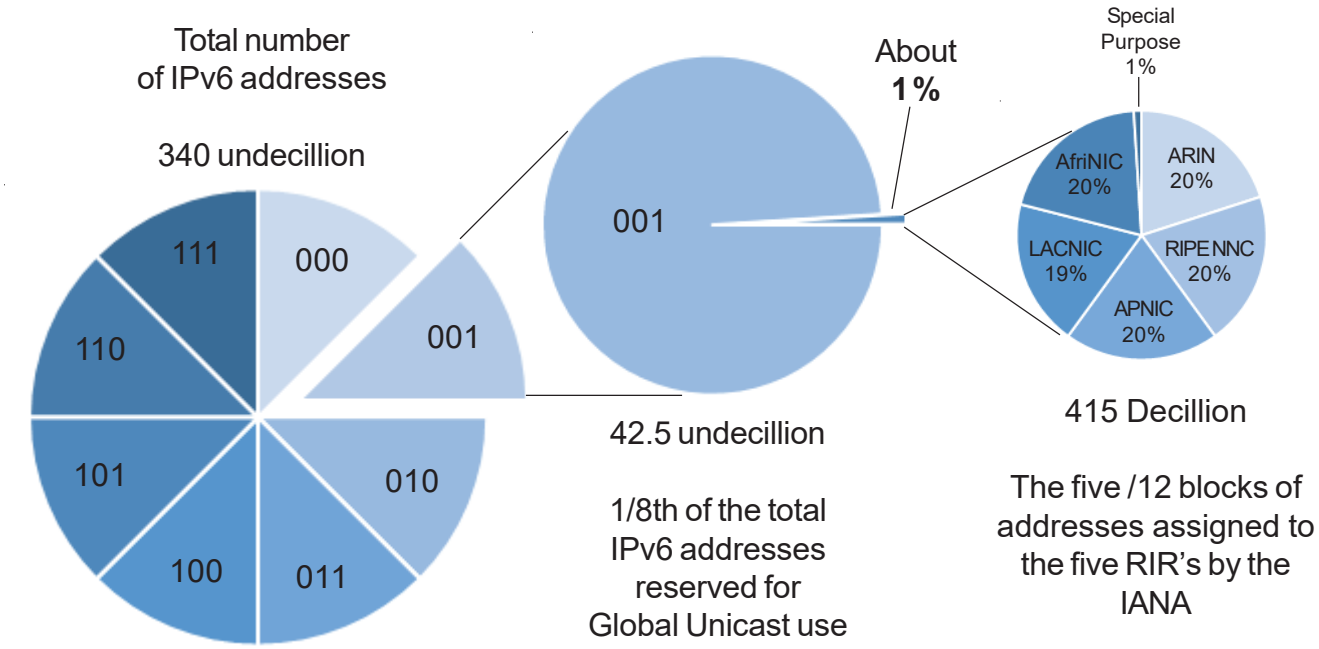
If you want to actually say the number it is three hundred and forty undecillion, two hundred and eighty-two decillion, three hundred and sixty-six nonillion, nine hundred and twenty octillion, nine hundred and thirty-eight septillion, four hundred and sixty-three sextillion, four hundred and sixty-three quintillion, three hundred and seventy-four quadrillion, six hundred and seven trillion, four hundred and thirty-one billion, seven hundred and sixty-eight million, two hundred and eleven thousand, four hundred and fifty-six. (or you can have Windows Narrator say it for you.)



The Internet Assigned Numbers Authority (IANA) divided the available IPv6 addresses into eight equal segments based on the three leading bits of the addresses (000, 001, 010, 011, 100, 101, 110, and 111). Only one eighth of the total available addresses have been reserved for use as global unicast addresses. Four smaller subgroups have been made available for unique local unicast, link-local unicast, multicast, and (unspecified, loopback, embedded IPv4).

IPv6 by the Numbers

340,282,366,920,938,463,463,374,607,431,768,211,456	Total number of IPv6 Addresses
42,535,295,865,117,307,932,921,825,928,971,026,432	1/8 or the reserved Global Unicast addresses
415,383,748,682,786,210,282,439,706,337,607,680	The five /12 ranges assigned to the RIRs
7,119,157,000	Estimated world population
58,347,322,398,253,923,924,200,534	Estimated number of IPv6 addresses per person (That's over 58 septillion addresses per person and doesn't include the additional smaller blocks of addresses assigned to the five RIRs by the IANA)



The Five RIRs

The **Regional Internet Registry** is an organization that manages the allocation and registration of internet number resources world wide. It has evolved over time to divide the world into five areas, or RIRs.

AfriNIC - African Network Information Centre
ARIN - American Registry for Internet Numbers
APNIC - Asia-Pacific Network Information Centre
LACNIC - Latin America and Caribbean Network Information Centre
RIPE NCC - Réseaux IP Européens Network Coordination Centre

To make IPv6 addresses a little less imposing, two rules were developed to make them easier to work with. Rule 1: Omission of the Leading 0s, and Rule 2: Omission of the all-0 Hextets.

Rule 1: Omission of the Leading 0s

Rule 1 allows you to remove all the leading 0s in each individual hextet.

Sample 1 Unspecified address

Preferred Format: **000**0:**000**0:**000**0:**000**0:**000**0:**000**0:**000**0:**000**0
Leading 0's removed: 0: 0: 0: 0: 0: 0: 0: 0
or
0:0:0:0:0:0:0:0

Sample 2 - Loopback Address

Preferred Format: **000**0:**000**0:**000**0:**000**0:**000**0:**000**0:**000**0:**000**1
Leading 0's removed: 0: 0: 0: 0: 0: 0: 0: 1
or
0:0:0:0:0:0:0:1

Sample 3 – Global Unicast Address

Preferred Format: 2000:**000**0:**000**0:**000**0:**000**0:**000**0:**000**0:**000**1
Leading 0's removed: 2000: 0: 0: 0: 0: 0: 0: 1
or
2000:0:0:0:0:0:0:1

Sample 4 – Global Unicast Address

Preferred Format: 2001:**00**FE:ACAD:2013:**000**0:**000**0:**00**AA:**0**271
Leading 0's removed: 2001: FE:ACAD:2013: 0: 0: AA: 271
or
2001: FE:ACAD:2013:0:0:AA:271

Sample 5 – Unique local Unicast Address

Preferred Format: FC80:**000**0:**000**0:ACAD:**000**0:**000**0:**000**0:**000**1
Leading 0's removed: FC80: 0: 0:ACAD: 0: 0: 0: 1
or
FC80:0:0:ACAD:0:0:0:1

Sample 6 – Link-local Address

Preferred Format: FE80:ACAD:**0000**:**0**197:**000**0:**000**0:**000**0:FF01
Leading 0's removed: FE80:ACAD: 0: 197: 0: 0: 0:FF01
or
FE80:ACAD:0:197:0:0:0:FF01

Sample 7 – Multicast Address

Preferred Format: FF00:**000**0:**000**0:ACAD:**000**0:**000**0:FE00:**0**721
Leading 0's removed: FF00: 0: 0:ACAD: 0: 0:FE00: 721
or
FF00:0:0:ACAD:0:0:FE00:721

Rule 1: Omission of the Leading 0s Problems

Using Rule 1 reduce the IPv6 addresses to their shortened form.

1. 0000:0000:0000:0000:0000:0000:0000:0000

0:0:0:0:0:0:0:0

2. 0000:0000:0000:0000:0000:0000:0000:0001

0:0:0:0:0:0:0:1

3. 2000:0000:0000:0000:0000:ABCD:0000:0025

2000:0:0:0:0:ABCD:0:25

4. 3F00:0090:0000:0000:0000:0098:0000:0001

3F00:90:0:0:0:98:0:1

5. 2001:3756:0005:0000:ACAD:0000:0000:0025

2001:3756:5:0:ACAD:0:0:25

6. 3FFF:FF00:0000:0000:ACAD:0000:0000:0127

3FFF:FF00:0:0:ACAD:0:0:127

7. 2001:0000:0000:ABCD:FFFF:0000:0000:0001

2001:0:0:ABCD:FFFF:0:0:1

8. 3ABC:0001:ACAD:0000:0000:1234:0000:0005

3ABC:1:ACAD:0:0:1234:0:5

9. FC00:0000:0000:0000:3E00:1275:0000:0034

FC00:0:0:0:3E00:1275:0:34

10. FE95:FC6C:C540:0000:0000:0000:0000:9800

FE95:FC6C:C540:0:0:0:0:9800

11. FF00:ACAD:0000:0000:1234:0000:0000:0001

FF00:ACAD:0:0:1234:0:0:1

Rule 2: Omission of the All-0 Hextets

Rule 2 uses a double colon :: to represent a single contiguous set of all zero hextexts. It can only be used once in any IPv6 address.

Sample 1 Unspecified address

Preferred Format: **0000**:**0000**:**0000**:**0000**:**0000**:**0000**:**0000**:**0000**
Contiguous 0's removed: ::

Sample 2 - Loopback Address

Preferred Format: **0000**:**0000**:**0000**:**0000**:**0000**:**0000**:**0000**:0001
Contiguous 0's removed: ::0001

Sample 3 – Global Unicast Address

Preferred Format: 2000:**0000**:**0000**:**0000**:**0000**:**0000**:**0000**:0001
Contiguous 0's removed: 2000: :0001
or
2000::0001

Sample 4 – Global Unicast Address

Preferred Format: 2001:00FE:ACAD:2013:**0000**:**0000**:00AA:0271
Contiguous 0's removed: 2001:00FE:ACAD:2013: :00AA:0271
or
2001:00FE:ACAD:2013::00AA:0271

Sample 5 – Unique local Unicast Address

Preferred Format: FC80:0000:0000:ACAD:**0000**:**0000**:**0000**:0001
Contiguous 0's removed: FC80:0000:0000:ACAD: :0001
or
FC80:0000:0000:ACAD::0001

Sample 6 – Link-local Address

Preferred Format: FE80:ACAD:0000:0197:**0000**:**0000**:**0000**:FF01
Contiguous 0's removed: FE80:ACAD:0000:0197: :FF01
or
FE80:ACAD:0000:0197::FF01

Sample 7 – Multicast Address

Preferred Format: FF00:**0000**:**0000**:ACAD:**0000**:**0000**:FE00:0721
Contiguous 0's removed: FF00: :ACAD:0000:0000:FE00:0721 (Option #1)
FF00:0000:0000:ACAD: :FE00:0721 (Option #2)
or
FF00::ACAD:0000:0000:FE00:0721 (Option #1)
FF00:0000:0000:ACAD::FE00:0721 (Option #2)

Rule 2: Omission of the All-0 Hextets Problems

Using Rule 2 reduce the IPv6 addresses to their shortened form.

1. 0000:0000:0000:0000:0000:0000:0000:0000

::

2. 0000:0000:0000:0000:0000:0000:0000:0001

::1

3. 2000:0000:0000:0000:0000:ABCD:0000:0025

2000::ABCD:0:25

4. 3F00:0090:0000:0000:0000:0098:0000:0001

3F00:90::98:0:1

5. 2001:3756:0005:0000:ACAD:0000:0000:0025

2001:3756:5:0:ACAD::25

6. 3FFF:FF00:0000:0000:ACAD:0025:0000:0127

3FFF:FF00::ACAD:25:0:127

7. 2001:ACAD:0000:ABCD:FFFF:0000:0000:0001

2001:ACAD:0:ABCD:FFFF::1

8. 3ABC:0001:ACAD:0000:0000:1234:0000:0005

3ABC:0001:ACAD::1234:0:5

9. FC00:0000:0000:0000:3E00:1275:0000:0034

FC00::3E00:1275:0:34

10. FE95:FC6C:C540:0000:0000:0000:0000:9800

FE95:FC6C:C5A0::9800

11. FF00:ACAD:0000:0000:1234:0000:0000:0001

FF00:ACAD:0:0:1234::1

Combining Rule 1 and Rule 2

To reduce the size of IPv6 address even more you can combine Rule 1 with Rule 2.

Sample 1 Unspecified address

Preferred Format: **0000**:**0000**:**0000**:**0000**:**0000**:**0000**:**0000**:**0000**
Combined reduction: ::

Sample 2 - Loopback Address

Preferred Format: **0000**:**0000**:**0000**:**0000**:**0000**:**0000**:**0000**:0001
Combined reduction: ::1

Sample 3 – Global Unicast Address

Preferred Format: 2000:**0000**:**0000**:**0000**:**0000**:**0000**:**0000**:**000**1
Combined reduction: 2000: :1
or
2000::1

Sample 4 – Global Unicast Address

Preferred Format: 2001:**00**FE:ACAD:2013:**0000**:**0000**:**00**AA:**0**271
Combined reduction: 2001: FE:ACAD:2013: : AA: 271
or
2001:FE:ACAD:2013::AA:271

Sample 5 – Unique local Unicast Address

Preferred Format: FC80:**000**0:**000**0:ACAD:**0000**:**0000**:**0000**:**000**1
Combined reduction: FC80: 0: 0:ACAD: : 1
or
FC80:0:0:ACAD::1

Sample 6 – Link-local Address

Preferred Format: FE80:ACAD:**000**0:**0**197:**0000**:**0000**:**0000**:FF01
Combined reduction: FE80:ACAD:0 : 197: :FF01
or
FE80:ACAD:0:197::FF01

Sample 7 – Multicast Address

Preferred Format: FF00:**0000**:**0000**:ACAD:**0000**:**0000**:FE00:**0**721
Combined reduction: FF00: :ACAD: 0: 0:FE00: 721 (Option #1)
FF00: 0: 0:ACAD: :FE00: 721 (Option #2)
or
FF00::ACAD:0:0:FE00:721 (Option #1)
FF00:0:0:ACAD::FE00:721 (Option #2)

Combining Rule 1 and Rule 2 Problems

Using Rule 2 reduce the IPv6 addresses to their shortest form.

1. 0000:0000:0000:0000:0000:0000:0000:0000

::

2. 0000:0000:0000:0000:0000:0000:0000:0001

::1

3. 2000:0000:0000:0000:0000:ABCD:0000:0025

2000::ABCD:0:25

4. 3F00:0090:0000:0000:0000:0098:0000:0001

3F00:90::98:0:1

5. 2001:3756:0005:0000:ACAD:0000:0000:0025

2001:3756:5:0:ACAD::25

6. 3FFF:FF00:0000:0000:ACAD:0025:0000:0127

3FFF:FF00::ACAD:25:0:127

7. 2001:ACAD:0000:ABCD:FFFF:0000:0000:0001

2001:ACAD:0:ABCD:FFFF::1

8. 3ABC:0001:ACAD:0000:0000:1234:0000:0005

3ABC:1:ACAD::1234:0:5

9. FC00:0000:0000:0000:3E00:1275:0000:0034

FC00::3E00:1275:0:34

10. FE95:FC6C:C540:0000:0000:0000:0000:9800

FE95:FC6C:C540::9800

11. FF00:ACAD:0000:0000:1234:0000:0000:0001

FF00:ACAD::1234:0:0:1

Reverting Reduced Address Problems

The following addresses have been shorted using Rule1 and/or Rule 2. Expand them back to their preferred format.

Sample: FF00:ACAD:ABCD:0:1234::1

FF00:ACAD:ABCD:0000:1234:0000:0000:0001

1. 2000::1

2000:0000:0000:0000:0000:0000:0000:0001

2. ::1

0000:0000:0000:0000:0000:0000:0000:0001

3. 2001:0:0:0:0:ABCD:0:127

2001:0000:0000:0000:0000:ABCD:0000:0127

4. 3E80:0070::0098:0000:0001

3E80:0070:0000:0000:0000:0098:0000:0001

5. 2FFF:38:5:0:ACAD::5

2FFF:0038:0005:0000:ACAD:0000:0000:0005

6. 3FFF::ACAD:25:0:100

3FFF:0000:0000:0000:ACAD:0025:0000:0100

7. 2002:ACAD:0:1BCD:FFFF::4

2002:ACAD:0000:1BCD:FFFF:0000:0000:0004

8. 3FAA:0025:ACAD::ABCD:0000:0005

3FAA:0025:ACAD:0000:0000:ABCD:0000:0005

9. FFFF::4E00:1235:0:34

FFFF:0000:0000:0000:4E00:1235:0000:0034

10. 3E01:6C:40::9800

3E01:006C:0040:0000:0000:0000:0000:9800