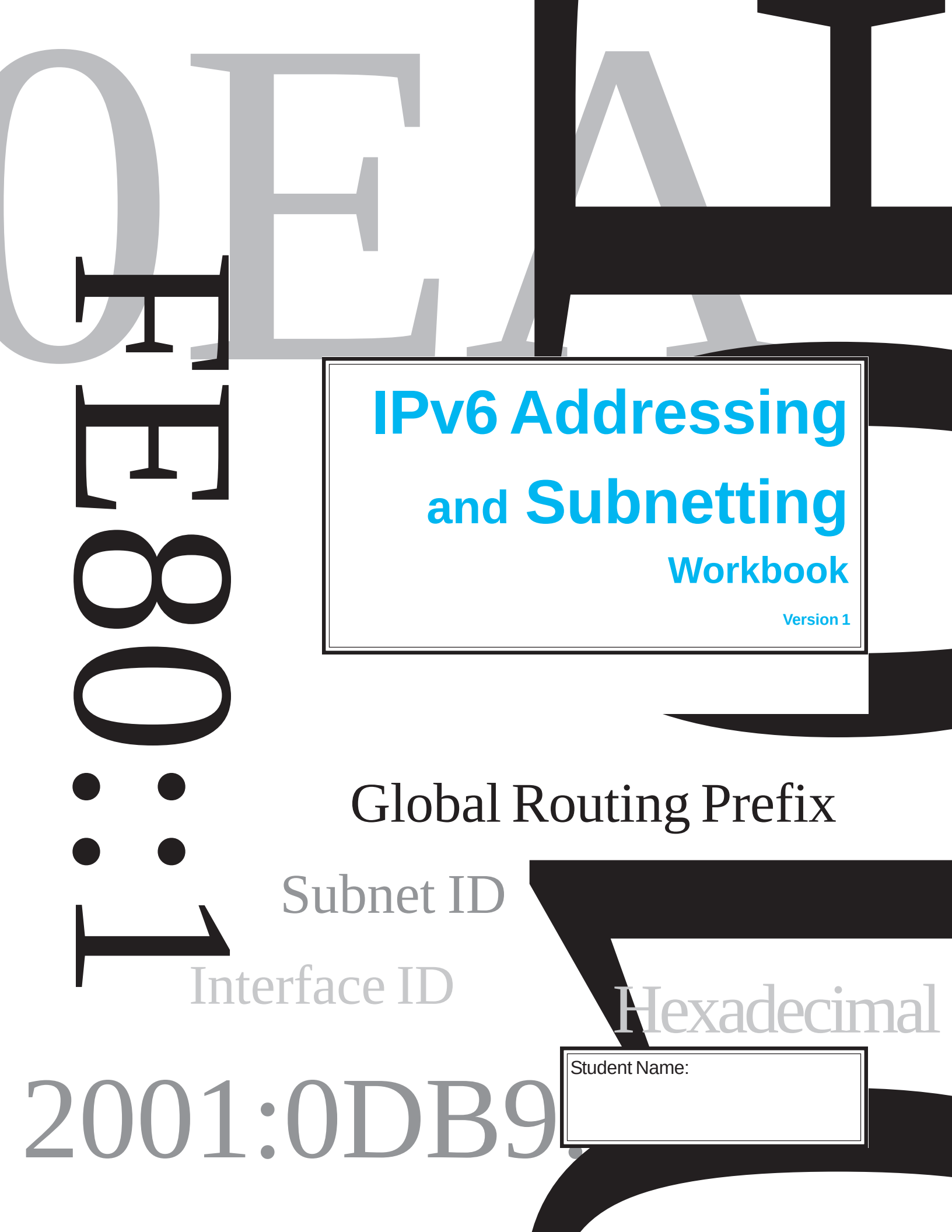

IPv6 Addressing and Subnetting

Workbook

Version 1

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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Special Thanks to Melvin Baker and Jim Dorsch for taking the time to check this workbook for errors, and to everyone who has sent in suggestions to improve the series.

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.

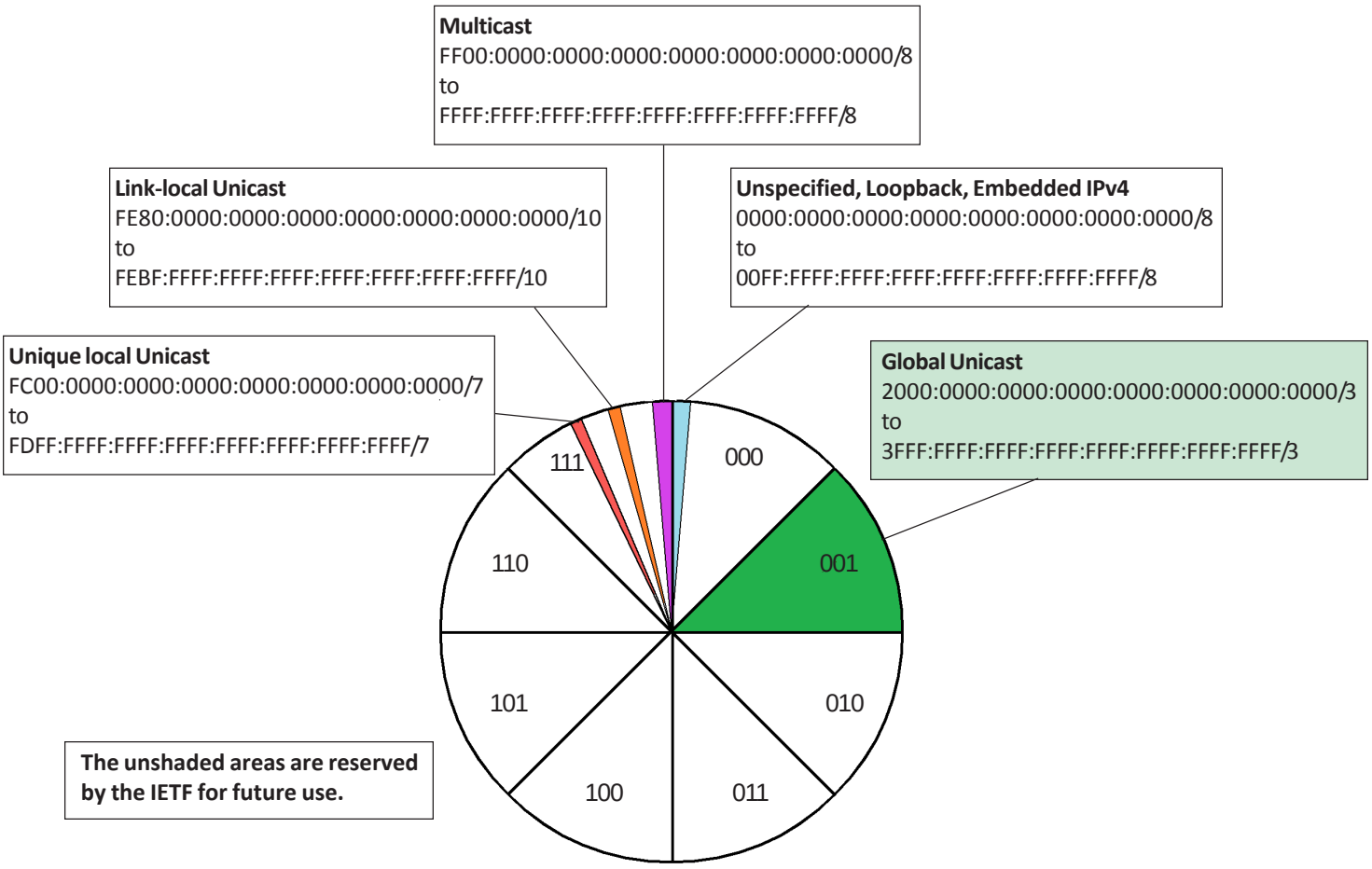
1998 - The more fully developed IPv6 obsoletes RFC 1883 with the updated RFC 2460.

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.

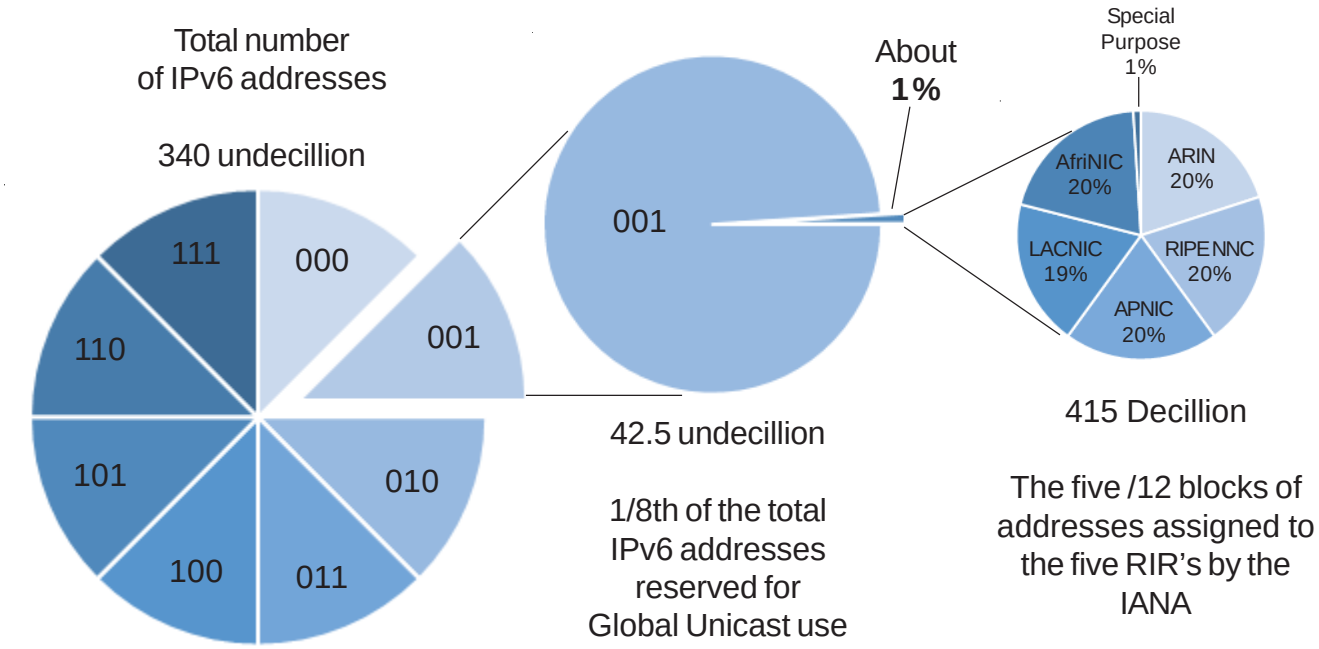
If you want to actually say the number it is three hundred and forty undecillion, two hundred and eighty-two decillion, three hundred and sixty-six nonillion, nine hundred and twenty octillion, nine hundred and thirty-eight septillion, four hundred and sixty-three sextillion, four hundred and sixty-three 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)



42.5 undecillion

1/8th of the total IPv6 addresses reserved for Global Unicast use

415 Decillion

The five /12 blocks of addresses assigned to the five RIR's by the IANA

There are some additional smaller blocks of addresses assigned to the five RIRs

There is a chart in the Reference Section that has all of these listed.

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

_____

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

_____

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

_____

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

_____

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

_____

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

_____

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

_____

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

_____

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

_____

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

_____

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

_____

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

_____

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

_____

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

_____

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

_____

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

_____

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

_____

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

_____

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

_____

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

_____

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

_____

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

_____

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

_____

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

_____

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

_____

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

_____

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

_____

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

_____

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

_____

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

_____

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

_____

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

_____

2. ::1

_____

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

_____

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

_____

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

_____

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

_____

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

_____

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

_____

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

_____

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

_____

IPv6 Address Categories

All IPv6 addresses fall into one of three categories

Unicast -

Unicast addresses identify a unique interface on an IPv6 device.
It is a one to one connection between a source and destination.

Examples of IPv6 Unicast addresses include:

Global Unicast -
Similar to a public IPv4 address
Can be used as a public address on the internet
Globally unique
Can be static or dynamic

Link-Local -
Only used on a local network link to uniquely identify a host
Not routable on the public internet
No router will forward a link-local address
Every IPv6 enabled networked device is required to have a link-local address
Multiple interfaces on the same device can have the same link-local address

Loopback - (::1/128)
Used by a host to ping itself to test the TCP/IP stack
It cannot be assigned to a physical interface

Unspecified Address - (::/128)
Is only used as a source address to indicate the absence of an actual address

Unique Local -
Unique local addresses are roughly the same as IPv4 private addresses

Embedded IPv4 -
Used to transition IPv4 networks into IPv6

Multicast -

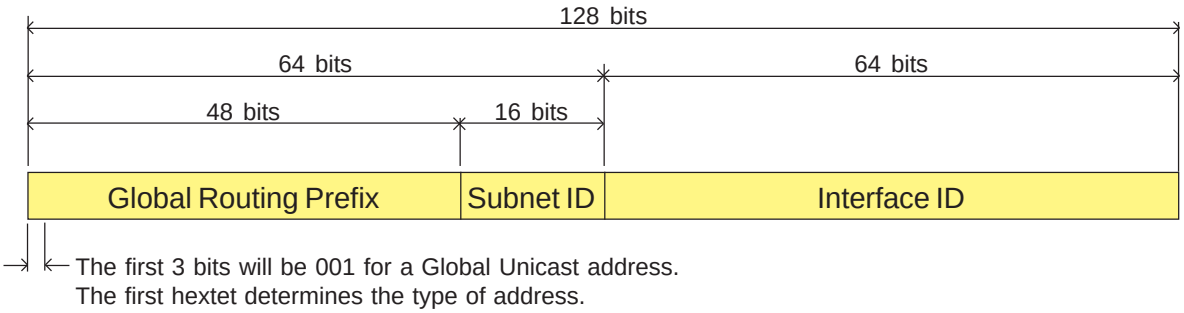
Multicast addresses are used to send a single packet to multiple destinations simultaneously.

Anycast -

Anycast addresses are described as a one-to-nearest or one-to-one-of-many packet delivery. For example, all routers in the same network will be assigned the same Anycast address. A packet sent to that address will only be delivered to the closest router with that address based on routing protocol metrics. Anycast addresses can be pulled from Global Unicast, Site-Local, or Link-Local address ranges. The first address and the last 128 addresses in a /64 Global Unicast range are reserved as the Subnet-Router Anycast Address.

There are no broadcast addresses in IPv6.

Global Unicast IPv6 Address



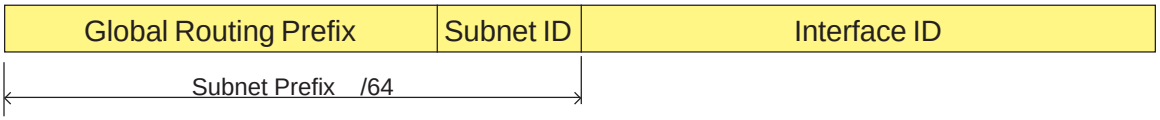
Global Routing Prefix -
This is assigned by the ISP to a customer or site.
The Global Routing Prefix is determined by the *prefix-length* notation. (example /48 or /64).
This is similar to the network portion of an IPv4 address.

Subnet ID -
This is similar to the subnet portion of an IPv4 address.
The difference is in IPv4 the subnet is borrowed from the host portion of the address.
In IPv6 the Subnet ID is a separate field (/48 to /64) and not necessarily part of the Interface ID.

Interface ID -
The Interface ID uniquely identifies a interface on the local subnet.

Subnet Prefix

The Subnet Prefix is the address space used by the Global Routing Prefix and the Subnet ID, and can range from 0 to 128. The preferred Subnet Prefix length is /48 to /64 for customers or sites.



RFC 4291 recommends that the Interface-ID or host portion of your IPv6 address be 64 bits.
A minimum /64 prefix length is required to support Stateless Address Auto-configuration.

IPv6 Prefix Length vs IPv4 CIDR

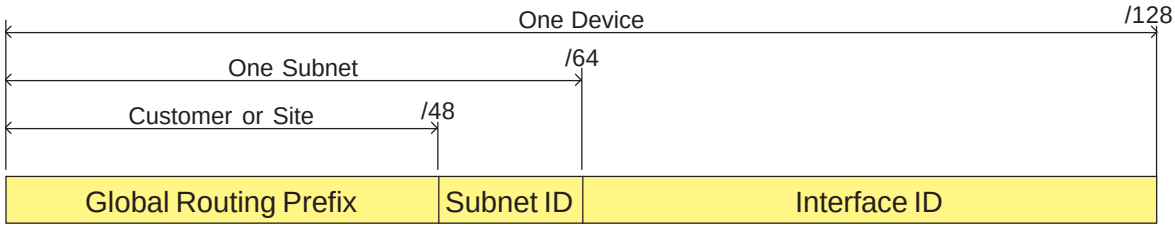
In IPv4 the network portion of the IP address is indicated with a dotted-decimal subnet mask; such as 255.255.255.0. It can also be identified with a CIDR (classless interdomain routing) notation; such as /24.

IPv6 does not use either of these terms to indicate the network portion of an IPv6 address. The network portion of the address is indicated with a **Prefix Length** at the end of the address. While a /48 or /56 looks like a CIDR notation it is not a classless interdomain routing notation. The prefix length indicates the number of nibbles or bits used in the network or subnetwork portion of an IPv6 address.

Global Unicast Prefix Allocations

In 2001, RFC 3177 was written to provide recommendations for how IPv6 Global Unicast addresses should be allocated to customers or Sites.

> "In particular, it recommends the assignment of /48 in the general case, /64 when it is known that one and only one subnet is needed and /128 when it is absolutely known that one and only one device is connecting."

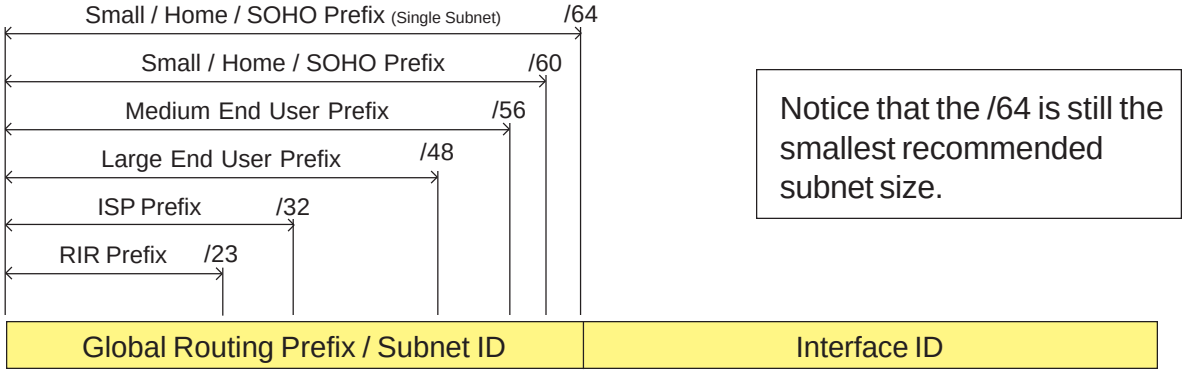


A /48 prefix allows each customer or Site to have 1,208,925,819,614,629,174,706,176 addresses. These can be used as a single subnet, or up to 65,536 subnets with a /64 prefix-length.

The Regional Internet Registries (RIRs) adopted RTC 3177 recommendation in 2002, but began reconsidering the policy in 2005. In March of 2011 RTC 6177 obsoleted RTC 3177 with a new recommendation.

> "The exact choice of how much address space to assign end sites is an issue for the operational community."

This gives local ISPs more options when assigning IPv6 addresses to their customers or Sites.



Notice that the /64 is still the smallest recommended subnet size.

Typical IPv6 Prefix Assignments:

Subscribers	Prefix-Length	# of Subnets at /64	Total number of Possible Addresses
RIR	/23	2,199,023,255,552	40,564,819,207,303,340,847,894,502,572,032
Service Provider (*LIR) -	/32	4,294,967,296	79,228,162,514,264,337,593,543,950,336
Large End User -	/48	65,536	1,208,925,819,614,629,174,706,176
Medium End User -	/56	256	4,722,366,482,869,645,213,696
Small / Home / SOHO -	/60	16	295,147,905,179,352,825,856
Small / Home / SOHO -	/64	1	18,446,744,073,709,551,616

**Local Internet registry*

Subnetting on the Nibble Boundary

One of the design themes driving IPv6 was to keep subnetting as simple as possible. The forth hextet is reserved for subnetting, giving network administrators multiple options for developing a network plan. In order to keep IPv6 addressing as simple as possible it is a **Best Practice** to subnet on the nibble boundary.

Every IPv6 address is comprised of 128 bits, which is represented with 32 hexadecimal numbers.

2001:ACAD:1234:0000:0000:0000:0000:0000/48

Showing this address with 128 binary characters makes it difficult to read and almost impossible for most people to work with.

0010000000000001:1010110010101101:0001001000110100:0000000000000000:
0000000000000000:0000000000000000:0000000000000000:0000000000000000

Each hexadecimal number in an IPv6 address represents 4 bits or a Nibble. An IPv6 address is composed of 32 hexadecimal numbers or 32 Nibbles.

2001:ACAD:1234:**0000**:0000:0000:0000:0000/48

IPv6 can be subnetted just like IPv4 using individual binary bits. To keep subnetting as simple as possible it is a **Best Practice** to borrow 4 bits, or one Nibble at a time.

Nibble Boundary Subnets

(Subnetting on the Nibble Boundary)

Prefix	# of /64 subnets
/48	65,536
/52	4096
/56	256
/60	16
/64	1

It is a Best Practice to subnet on the Nibble Boundary.

Subnets Based on Individual Binary Bits

(Subnetting within a Nibble)

Prefix	# of /64 subnets
/48	**65,536**
/49	32,768
/50	16,384
/51	8,192
/52	**4,096**
/53	2,048
/54	1,024
/55	512
/56	**256**
/57	128
/58	64
/59	32
/60	**16**
/61	8
/62	4
/63	2
/64	**1**

Site ID and Sub-Site IDs

Subnetting on the nibble boundary allows you to easily set up proper route aggregation and summarization to use for each subnet or location. It also allows for easier deployment of firewalls based on location or network users. In order to do this you need to assign Site ID's and Sub-Site ID's as necessary. The Site ID is the first address in the subnet you have assigned to a specific location or user group. Sub-Site ID's come into play if you subnet a location or user group into smaller subnets. The first address in each range becomes the Sub-Site ID.

Subnetting on the Nibble boundary gives you these subnetting options.

/48 No Nibbles	/52 1 Nibble	/56 2 Nibbles	/60 3 Nibbles	/64 4 Nibbles
/48 - 1 Subnet				
/52 - 16 Subnets	/52 - 1 Subnet			
/56 - 256 Subnets	/56 - 16 Subnets	/56 - 1 Subnets		
/60 - 4096 Subnets	/60 - 256 Subnets	/60 - 16 Subnets	/60 - 1 Subnets	
/64 - 65,536 Subnets	/64 - 4096 Subnets	/64 - 256 Subnets	/64 - 16 Subnets	/64 - 1 Subnet

As an example, your company has two offices, and within each office there are several groups you want on separate subnets. The groups include: Infrastructure, Management, Marketing, Finance, Research, Warehouse, and Sales.

Your ISP has assigned your company the IPv6 address 2001:ACAD:1234::/48. You will need one Site ID for each office. A /52 Subnet Prefix will give you 16 subnets, or you could use a /56 Subnet Prefix and have 256 subnets. For our purposes we 'll use the /56 Subnet Prefix.

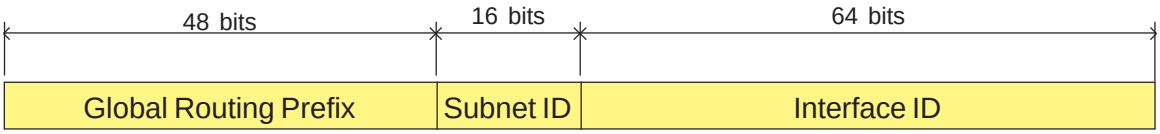
Our original IPv6 Range was: 2001:ACAD:1234::/48. Subnetting this address with a /56 Subnet Prefix will take two nibbles from the Subnet ID and give you the following address ranges:

2001:ACAD:1234:**00**00::/56 Save this range for over all infrastructure needs.
2001:ACAD:1234:**01**00::/56 This becomes the Site ID for Office 1.
2001:ACAD:1234:**02**00::/56 This becomes the Site ID for Office 2.
2001:ACAD:1234:**03**00::/56
(Lots of subnets omitted)
2001:ACAD:1234:**FF**00::/56

Office 1 needs subnets for Infrastructure, Management, and Sales. Subnet the Site ID for Office 1 with a /60 Subnet Prefix.

2001:ACAD:1234:01**0**0::/60 This becomes the Sub-Site ID for Infrastructure needs.
2001:ACAD:1234:01**1**0::/60 This becomes the Sub-Site ID for Managment.
2001:ACAD:1234:01**2**0::/60 This becomes the Sub-Site ID for Sales.
(Lots of subnets omitted)
2001:ACAD:1234:01**F**0::/60

Subnetting IPv6



Unlike IPv4 which requires you to borrow bits from the host portion, IPv6 has 16 bits or four hexadecimal numbers built into the address specifically allocated for creating subnets. A /48 address will allow you to have a single subnet or up to 65,536 subnets.

Lets say that your ISP has assigned you the 2001:ACAD:1234::/48 IPv6 address.

Global Routing Prefix	Subnet ID	Interface ID
2001:ACAD:1234:	**0000**	:0000:0000:0000:0000

Basic subnetting in IPv6 was designed to make subnetting a very simple process. Start at the /64 bit and start counting up until you've used all the available bits in the subnet ID.
It really is that simple!

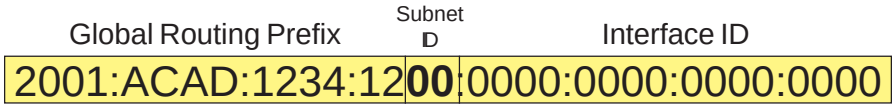
2001:ACAD:1234:**0000**:0000:0000:0000:0000/64	1st subnet
2001:ACAD:1234:**0001**:0000:0000:0000:0000/64	2nd subnet
2001:ACAD:1234:**0002**:0000:0000:0000:0000/64	3rd subnet
2001:ACAD:1234:**0003**:0000:0000:0000:0000/64	4th subnet
2001:ACAD:1234:**0004**:0000:0000:0000:0000/64	5th subnet
2001:ACAD:1234:**0005**:0000:0000:0000:0000/64	6th subnet
2001:ACAD:1234:**0006**:0000:0000:0000:0000/64	7th subnet
2001:ACAD:1234:**0007**:0000:0000:0000:0000/64	8th subnet
2001:ACAD:1234:**0008**:0000:0000:0000:0000/64	9th subnet
2001:ACAD:1234:**0009**:0000:0000:0000:0000/64	10th subnet
2001:ACAD:1234:**000A**:0000:0000:0000:0000/64	11th subnet
2001:ACAD:1234:**000B**:0000:0000:0000:0000/64	12th subnet
2001:ACAD:1234:**000C**:0000:0000:0000:0000/64	13th subnet
2001:ACAD:1234:**000D**:0000:0000:0000:000064	14th subnet
2001:ACAD:1234:**000E**:0000:0000:0000:0000/64	15th subnet
2001:ACAD:1234:**000F**:0000:0000:0000:0000/64	16th subnet
2001:ACAD:1234:**0010**:0000:0000:0000:0000/64	17th subnet
2001:ACAD:1234:**0011**:0000:0000:0000:0000/64	18th subnet
2001:ACAD:1234:**0012**:0000:0000:0000:0000/64	19th subnet
2001:ACAD:1234:**0013**:0000:0000:0000:0000/64	20th subnet

Each subnet contains over 18 quintillion addresses.

(Lots of subnets omitted for space.)

2001:ACAD:1234:**FFFC**:0000:0000:0000:0000/64	65,533rd subnet
2001:ACAD:1234:**FFFD**:0000:0000:0000:0000/64	65,534th subnet
2001:ACAD:1234:**FFFE**:0000:0000:0000:0000/64	65,535th subnet
2001:ACAD:1234:**FFFF**:0000:0000:0000:0000/64	65,536th subnet

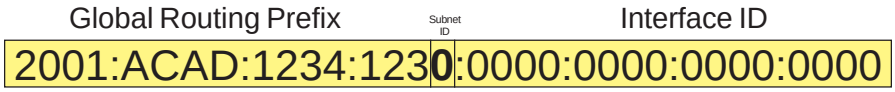
A Medium End user might receive a /56 IPv6 address from their ISP.



2001:ACAD:1234:12**00**:0000:0000:0000:0000/64	1st subnet
2001:ACAD:1234:12**01**:0000:0000:0000:0000/64	2nd subnet
2001:ACAD:1234:12**02**:0000:0000:0000:0000/64	3rd subnet
2001:ACAD:1234:12**03**:0000:0000:0000:0000/64	4th subnet
(Lots of subnets omitted for space.)	
2001:ACAD:1234:12**FD**:0000:0000:0000:0000/64	254th subnet
2001:ACAD:1234:12**FE**:0000:0000:0000:0000/64	255th subnet
2001:ACAD:1234:12**FF**:0000:0000:0000:0000/64	256th subnet

Each subnet contains over 18 quintillion addresses.

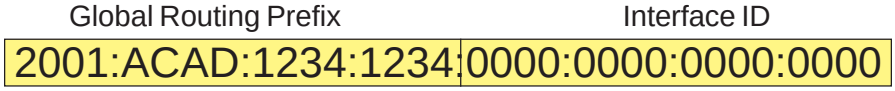
A Small End user might receive a /60 IPv6 address from their ISP.



2001:ACAD:1234:123**0**:0000:0000:0000:0000/64	1st subnet
2001:ACAD:1234:123**1**:0000:0000:0000:0000/64	2nd subnet
2001:ACAD:1234:123**2**:0000:0000:0000:0000/64	3rd subnet
2001:ACAD:1234:123**3**:0000:0000:0000:0000/64	4th subnet
2001:ACAD:1234:123**4**:0000:0000:0000:0000/64	5th subnet
2001:ACAD:1234:123**5**:0000:0000:0000:0000/64	6th subnet
2001:ACAD:1234:123**6**:0000:0000:0000:0000/64	7th subnet
2001:ACAD:1234:123**7**:0000:0000:0000:0000/64	8th subnet
2001:ACAD:1234:123**8**:0000:0000:0000:0000/64	9th subnet
2001:ACAD:1234:123**9**:0000:0000:0000:0000/64	10th subnet
2001:ACAD:1234:123**A**:0000:0000:0000:0000/64	11th subnet
2001:ACAD:1234:123**B**:0000:0000:0000:0000/64	12th subnet
2001:ACAD:1234:123**C**:0000:0000:0000:0000/64	13th subnet
2001:ACAD:1234:123**D**:0000:0000:0000:0000/64	14th subnet
2001:ACAD:1234:123**E**:0000:0000:0000:0000/64	15th subnet
2001:ACAD:1234:123**F**:0000:0000:0000:0000/64	16th subnet

Each subnet contains over 18 quintillion addresses.

A Home or single Site might receive a /64 IPv6 address from their ISP.



2001:ACAD:1234:1234:0000:0000:0000:0000/64	1 subnet

Over 18 quintillion addresses

Common Prefix's and Number of Subnets

Using the Subnet ID, the common Subnet Prefix's available from your ISP are /48, /52, /56, /60, and /64. The ISP could assign a lower Prefix Length, but most business will not need more than 65,536 subnets per Site.

The commonly available /64 subnets are:

/48	65,536 subnets
/52	4096 subnets
/56	256 subnets
/60	16 subnets
/64	1 subnet

Each /64 subnet contains over 18 quintillion addresses.

Notice that the Subnet ID always changes by four even though we're only using a single hexadecimal character.

Each hexadecimal character equals 4 binary numbers.

(/48, /52, /56, /60, /64)

With IPv4 the main concern was using the fewest possible number of addresses through creative subnetting.

The primary concern with IPv6 is making sure you have a prefix length that will cover all the subnets your Site will require and allow for future growth.

Basic Subneting Problems

Sample Problem

Your ISP has given you the IPv6 address 2001:FE12:A231::/48.

How many /64 subnets are available with this address? 65,536

What are the first six /64 subnets?

2001:FE12:A231::/64

2001:FE12:A231:1::/64

2001:FE12:A231:2::/64

2001:FE12:A231:3::/64

2001:FE12:A231:4::/64

2001:FE12:A231:5::/64

Problem 1

Your ISP has given you the IPv6 address 2000:ACAD:1234:6600::/56.

How many /64 subnets are available with this address? _____

What are the first four /64 subnets?

_____

_____

_____

_____

What are the last two /64 subnets in this range?

_____

_____

Problem 2

Your ISP has given you the IPv6 address 3FFF:5801:DEAF::/48.

How many /64 subnets are available with this address? _____

What are the first four /64 subnets?

_____

_____

_____

_____

What are the last two /64 subnets in this range?

_____

_____

Problem 3

Your ISP has given you the IPv6 address 2001:ACAD:5678:1840::/60.

How many /64 subnets are available with this address? _____

Complete the /64 subnets in this range. (The ISP's Global Routing Prefix is already printed for you.)

2001:ACAD:5678: _____

2001:ACAD:5678: _____

2001:ACAD:5678: _____

2001:ACAD:5678: _____

2001:ACAD:5678: _____

2001:ACAD:5678: _____

2001:ACAD:5678: _____

2001:ACAD:5678: _____

2001:ACAD:5678: _____

2001:ACAD:5678: _____

2001:ACAD:5678: _____

2001:ACAD:5678: _____

2001:ACAD:5678: _____

2001:ACAD:5678: _____

2001:ACAD:5678: _____

2001:ACAD:5678: _____

Problem 4

Your ISP has given you the IPv6 address 3100:6523:AD14:8000::/52.

How many /64 subnets are available with this address? _____

What are the first four /64 subnets? (The ISP's Global Routing Prefix is already printed for you.)

3100:6523:AD14:

3100:6523:AD14:

3100:6523:AD14:

3100:6523:AD14:

What are the last two /64 subnets in this range?

3100:6523:AD14:

3100:6523:AD14:

Problem 5

Your ISP has given you the IPv6 address 2100:89:4500::/48.

How many /64 subnets are available with this address? _____

What are the first four /64 subnets? (The ISP's Global Routing Prefix is already printed for you.)

2100:89:4500:

2100:89:4500:

2100:89:4500:

2100:89:4500:

What are the last two /64 subnets in this range?

2100:89:4500:

2100:89:4500:

IPv6 Subnetting Best Practices

IPv6 was designed to make subnetting as simple as possible by using ridiculously large blocks of addresses. Yes, it's wasteful! Most experts agree that IPv6 will last for 100 years and IP will be replaced before we run out of IPv6 address space.

So until the rules and/or the consensus of the experts change, these are the common subnets and best practices you will be working with. Information for subnets can be found in RFC & RTC documents, plus some additional resources listed in the Reference section of this workbook.

The common /64 subnets are:

You can negotiate with your ISP for a larger block
/48 65,536 subnets
/52 4096 subnets
/56 256 subnets
/60 16 subnets
/64 1 subnet

Specific Address Rules and Best Practices:

Point-To-Point Connections -

Best Practice: Use a /64 address range for these two addresses.

In rare cases this approach might present an issue with certain router setups where addresses are bounced back and forth between routers. Reducing the number of addresses in the range can also help avoid neighbor cache exhaustion attacks. (RFC 6164 - section 5)

Acceptable options include:
/127 -is recommended in RFC 6164. You must disable the router's Subnet-Router Anycast option to avoid issues with the all routers anycast address.
/126 -is discussed in RFC 2526. The /126 allows the all-zero reserved Anycast address to be avoided.
/120 - allows all the reserved anycast address to be avoided.
/112 - allows you to avoid the reserved anycast address, and gives you the entire four-digit hex value after the last colon.

Of all these options the /120 is probably the best choice since it avoids any issues with the Anycast addresses.

It is recommended that you reserve the entire /64 network with each of the above options.

/128 Single Address Subnets -

Best Practice: reserve the first subnet to use for infrastructure needs, such as loopback addresses, etc..

Acceptable option:
Allocate a full /64 range of addresses for each loopback address, but assign it a /128 subnet Prefix.

Anycast addresses -

Best Practice: Don't use the very first address or the last 128 addresses in any /64 network. These can only be assigned to an interface as an Anycast address.

Anycast addresses can be pulled from Global Unicast, Site-Local or Link-Local address ranges. Any address assigned to more than one interface on a subnet becomes an Anycast address. Anycast addresses can only be used by network devices, not a host. No anycast address can be used as the source address of an IPv6 packet.

The first address in every /64 subnet range is reserved for special use. The Interface ID is all zero's. (Example: 2001:ACAD:1234:5678:0000:0000:0000:0000/64) This address is the Subnet-Anycast Address. These addresses are typically used by different protocols such as Mobile IPv6. (RFC 4291)

The last eight bits in every /64 subnet range are reserved for Anycast addresses. These bits are 10000000 to 11111111. This means you can not assign any addresses if the last hextet falls between FF80 and FFFF unless it is a Anycast address. (RFC 2526)

If you try to apply the last 128 addresses to a router without setting them up as an Anycast address you will get the following error message.

```
Router(config-if)#ipv6 address 2001:ACAD:1234:5678:FFFF:FFFF:FFFF:FFFF/64
% 2001:DB8:1:1:FFFF:FFFF:FFFF:FFFF/64 should not be configured on FastEthernet0/0, a reserved anycast
```

Developing an Address Plan

(or IPv6 Subnetting in the Real World)

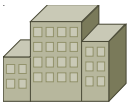
There is no one right way for developing an IPv6 addressing plan, but the recommended general guidelines include the following:

Step 1: Decide how you are going to divide your network:

a. by location
b. by user groups

Administration
Users Include:
Administration
Staff

Academic
Users Include:
Staff
Students



Dormitory
Users Include:
Staff
Students

Subnetting by Location:
To divide by location you would need four subnets. One for each building and one for the overall network infrastructure needs. You also need to hold several extra subnets in reserve for later growth.

Advantages:
This allows you to optimize your routing tables. All the networks within each location will aggregate to a single route.

Subnetting by User Groups:
To subnet the network by user groups you would need four subnets. One for Administration, Staff, and Students, plus one for overall network infrastructure needs. You also need to hold several extra subnets in reserve for later growth.

Advantages:
Subnetting by user groups makes it much easier to implement a security policy. Grouping by usage also helps track addresses for allocation and management.

Best Practice:
Subnetting by either location or user is acceptable. However, with the emphasis on network security, most networks are better served by subnetting user groups. It makes it much easier to maintain a higher level of security.

Step 2: Determine how many primary and secondary subnets your Site will need.

a. Create the primary subnets first.
b. Then create secondary subnets.

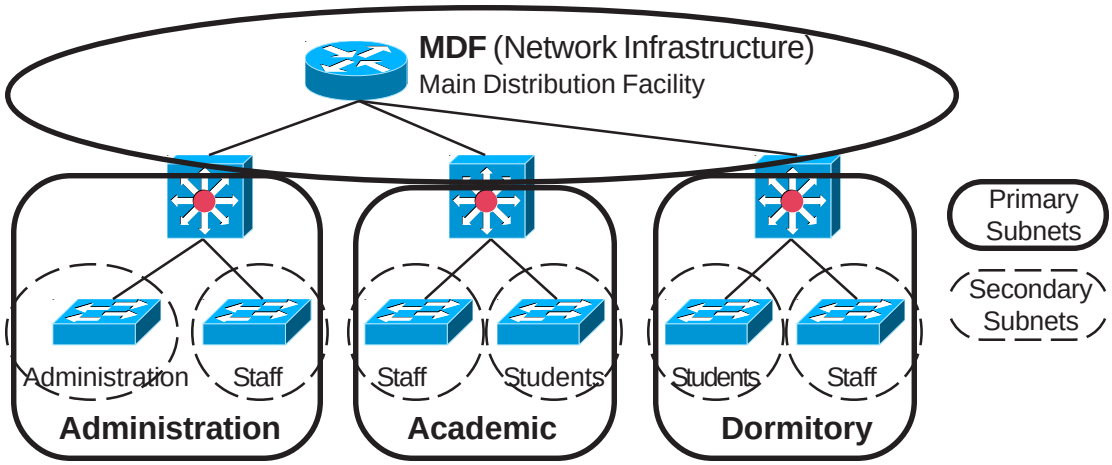
Subnetting by Location:

Primary Subnets: Quantity 4

With three buildings you will need four primary subnets. One for each building and one for the overall infrastructure needs.

Secondary Subnets: Quantity 6

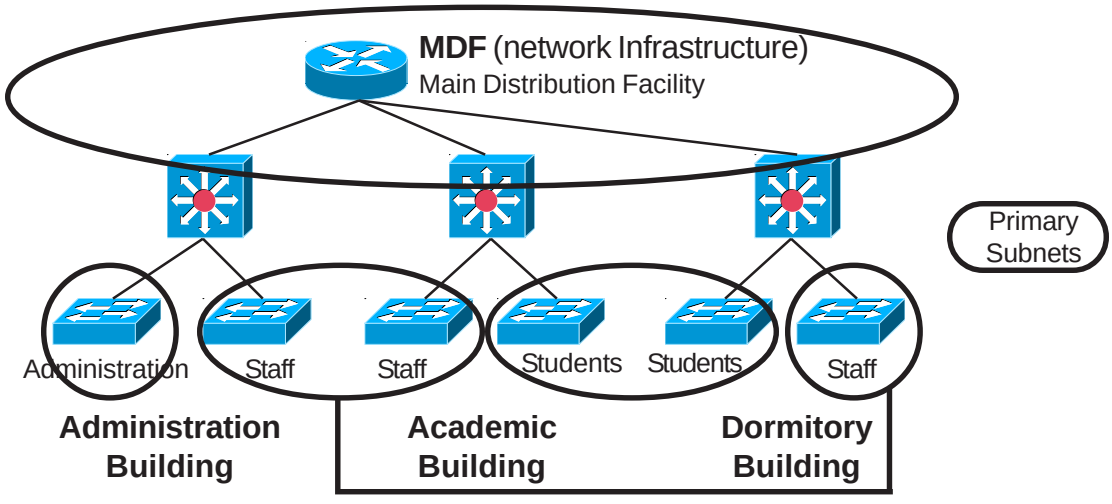
Administration will need two secondary subnets: Administration and Staff.
Academic will need two secondary subnets: Staff and Students.
Dormitory will need two secondary subnets: Staff and Students.



Subnetting by User Groups:

Primary Subnets: Quantity 4

With three user groups you will need four subnets. One for each group and one for the overall infrastructure needs.



Step 3: Based on the number of primary and secondary subnets needed assign the address ranges. The ISP has assigned you 2001:ACAD:1234::/48.

Subnetting Options:

/48 No Nibbles	/52 1 Nibble	/56 2 Nibbles	/60 3 Nibbles	/64 4 Nibbles
/48 - 1 Subnet				
/52 - 16 Subnets	/52 - 1 Subnet			
/56 - 256 Subnets	/56 - 16 Subnets	/56 - 1 Subnets		
/60 - 4096 Subnets	/60 - 256 Subnets	/60 - 16 Subnets	/60 - 1 Subnets	
/64 - 65,536 Subnets	/64 - 4096 Subnets	/64 - 256 Subnets	/64 - 16 Subnets	/64 - 1 Subnet

Subnetting by Location:

Primary Subnets: Quantity 4

With three buildings you will need four primary subnets. One for each building and one for the overall infrastructure needs.

Secondary Subnets: Quantity 6

Administration will need two secondary subnets: Administration and Staff.
Academic will need two secondary subnets: Staff and Students.
Dormitory will need two secondary subnets: Staff and Studewnts.

Take the addresses assigned to you by the ISP use one nibble and subnet it into 16 subnets using a /52 Subnet Prefix. This will give you the 4 primary subnets required with several to spare for future growth.

2001:ACAD:1234::/48 becomes:

- 2001:ACAD:1234:::/52 Site ID for over all infrastructure needs.
- 2001:ACAD:1234::**1**000:/52 Site ID for the Administration Building.
- 2001:ACAD:1234::**2**000:/52 Site ID for the Academic Building.
- 2001:ACAD:1234::**3**000:/52 Site ID for the Dormitory.
- 2001:ACAD:1234::**4**000:/52
  (Subnets omitted for space.)
- 2001:ACAD:1234::**F**000:/52

Site IDs and Sub-Site IDs will be the addresses found in the routing tables.

Take the second, third, and forth ranges and subnet them again by using the next Nibble with a /56 Subnet Prefix. This will create 16 subnets for each location.

Administration Building Site ID 2001:ACAD:1234:**1**000::/52 becomes:

- 2001:ACAD:1234:**1**000::/52 Administration Building Site ID
  - 2001:ACAD:1234::**10**00:/56 Sub-Site ID for infrastructure needs.
  - 2001:ACAD:1234::**11**00:/56 Sub-Site ID for Administration
  - 2001:ACAD:1234::**12**00:/56 Sub-Site ID for Staff

Academic Building Site ID 2001:ACAD:1234:**2**000::/52 becomes:

- 2001:ACAD:1234:**2**000::/52 Academic Building Site ID
  - 2001:ACAD:1234:**20**00::/56 Sub-Site ID for infrastructure needs.
  - 2001:ACAD:1234:**21**00::/56 Sub-Site ID for Students
  - 2001:ACAD:1234:**22**00::/56 Sub-Site ID for Staff

Dormitory Building Site ID 2001:ACAD:1234:**3**000::/52 becomes:

- 2001:ACAD:1234:**3**000::/52 Dormitory Building Site ID
  - 2001:ACAD:1234:**30**00::/56 Sub-Site ID for infrastructure needs.
  - 2001:ACAD:1234:**31**00::/56 Sub-Site ID for Students
  - 2001:ACAD:1234:**32**00::/56 Sub-Site ID for Staff

Subnetting by User Group:

Primary Subnets: Quantity 4

With three user groups you will need four primary subnets. One for each group and one for the overall infrastructure needs. In this example no secondary subnets are required.

Take the address assigned to you by the ISP use one nibble and subnet it into 16 subnets using a /52 Subnet Prefix. This will give you the 4 primary subnets required with several to spare for future growth.

2001:ACAD:1234::/48 becomes:

- 2001:ACAD:1234::/52 Site ID for over all infrastructure needs.
- 2001:ACAD:1234:**1**000::/52 Site ID for the Administration employees.
- 2001:ACAD:1234:**2**000::/52 Site ID for the Staff.
- 2001:ACAD:1234:**3**000::/52 Site ID for the Students.
- 2001:ACAD:1234:**4**000::/52

(Subnets omitted for space.)

- 2001:ACAD:1234:**F**000::/52

IPv6 Subnetting Problems

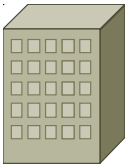
Subnetting on the Nibble Boundary

Sample Problem 1

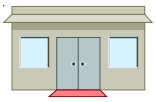
Using the **minimum number of subnets required** for the primary and secondary sites, design two IPv6 address plans that meets the following requirements. Create one plan for user groups and a second plan for location.

A coffee shop is opening three new stores and a central office/warehouse in your community and needs an IPv6 network plan developed. Each store will need secure network access for three groups: managers, the registers (which will monitor inventory and revenue), and wireless access for guests. The central office/warehouse will need secure network access for several departments: Managers, Finance, Human Relations.

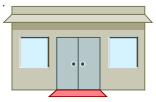
The ISP has given the company 2000:FE23:0054::/48.



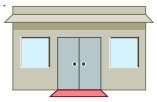
Central Office
Users Include:
Mangers
Finance
Human Relations



Store 1
Users Include:
Mangers
Registers
Wireless



Store 2
Users Include:
Mangers
Registers
Wireless



Store 3
Users Include:
Mangers
Registers
Wireless

Subnets Based on User Groups

ISP Address: 2000:FE23:0054::/48

- Infrastructure Site ID: 2000:FE23:0054::/52
- Managers Site ID: 2000:FE23:0054:1000::/52
- Finance Site ID: 2000:FE23:0054:2000::/52
- Human Relations Site ID: 2000:FE23:0054:3000::/52
- Registers Site ID: 2000:FE23:0054:4000::/52
- Wireless Site ID: 2000:FE23:0054:5000::/52

Subnets Based on Location

ISP Address: 2000:FE23:0054::/48

- Infrastructure Site ID: 2000:FE23:0054::/52
- Central Office Site ID: 2000:FE23:0054:1000::/52
  - Infrastructure Sub-Site ID: 2000:FE23:0054:1000::/56
  - Managers Sub-Site ID: 2000:FE23:0054:1100::/56
  - Finance Sub-Site ID: 2000:FE23:0054:1200::/56
  - Human Relations Sub-Site ID: 2000:FE23:0054:1300::/56
- Store 1 Site ID: 2000:FE23:0054:2000::/52
  - Infrastructure Sub-Site ID: 2000:FE23:0054:2000::/56
  - Managers Sub-Site ID: 2000:FE23:0054:2100::/56
  - Registers Sub-Site ID: 2000:FE23:0054:2200::/56
  - Wireless Sub-Site ID: 2000:FE23:0054:2300::/56
- Store 2 Site ID: 2000:FE23:0054:3000::/52
  - Infrastructure Sub-Site ID: 2000:FE23:0054:3000::/56
  - Managers Sub-Site ID: 2000:FE23:0054:3100::/56
  - Registers Sub-Site ID: 2000:FE23:0054:3200::/56
  - Wireless Sub-Site ID: 2000:FE23:0054:3300::/56
- Store 3 Site ID: 2000:FE23:0054:4000::/52
  - Infrastructure Sub-Site ID: 2000:FE23:0054:4000::/56
  - Managers Sub-Site ID: 2000:FE23:0054:4100::/56
  - Registers Sub-Site ID: 2000:FE23:0054:4200::/56
  - Wireless Sub-Site ID: 2000:FE23:0054:4300::/56

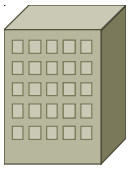
IPv6 Subnetting Problems
Subnetting on the Nibble Boundary

Sample Problem 2

Using the **minimum number of subnets required** for the primary and secondary sites, design two IPv6 address plans that meets the following requirements. Create one plan for user groups and a second plan for location.

A Medical Building is opening in your community and needs an IPv6 network plan developed.

The ISP has given the company 2001:5378:8801::/48.



Medical Building

First Floor
Patient Check-in
Emergancy Room

Users Include:
Administrators
Staff
Guests

Second Floor
Nurses Station
Ward A

Users Include:
Staff
Guests

Subnets Based on User Groups

ISP Address: 2001:5378:8801::/48

- Infrastructure Site ID: 2001:5378:8801::/52
- Administrators Site ID: 2001:5378:8801:1000::/52
- Staff Site ID: 2001:5378:8801:2000::/52
- Guests Site ID: 2001:5378:8801:3000::/52

Subnets Based on Location

ISP Address: 2001:5378:8801::/48

- Infrastructure Site ID: 2001:5378:8801::/52
- First Floor Site ID: 2001:5378:8801:1000::/52
  - Infrastructure Sub-Site ID: 2001:5378:8801:1000::/56
  - Patient Check-in Sub-Site ID: 2001:5378:8801:1100::/56
    - Administrators Sub-Site ID: 2001:5378:8801:1100::/60
    - Staff Sub-Site ID: 2001:5378:8801:1110::/60
    - Guest Sub-Site ID: 2001:5378:8801:1120::/60
  - Emergency Room Sub-Site ID: 2001:5378:8801:1200::/56
    - Administrators Sub-Site ID: 2001:5378:8801:1200::/60
    - Staff Sub-Site ID: 2001:5378:8801:1210::/60
    - Guest Sub-Site ID: 2001:5378:8801:1220::/60
- Second Floor Site ID: 2001:5378:8801:2000::/52
  - Infrastructure Sub-Site ID: 2001:5378:8801:2000::/56
  - Nurses Station Sub-Site ID: 2001:5378:8801:2100::/56
    - Staff Sub-Site ID: 2001:5378:8801:2100::/60
    - Guest Sub-Site ID: 2001:5378:8801:2110::/60
  - Ward A Sub-Site ID: 2001:5378:8801:2200::/56
    - Staff Sub-Site ID: 2001:5378:8801:2200::/60
    - Guest Sub-Site ID: 2001:5378:8801:2210::/60

IPv6 Subnetting Problems

Subnetting on the Nibble Boundary

Problem 1

Using the minimum number of subnets required for the primary and secondary sites design two IPv6 address plans that meets the following requirements. Create one plan for location and the second plan for user groups.

The XYZ Film company is setting up a new office and needs an IPv6 network plan developed. The company will have the following departments:

The ISP has given the company 2001:EE00:2575::/48.

Administration Building	Production Building
Users Include:	Users Include:
Sales	Casting
Accounting	Editing
Distribution	

Subnets Based on User Groups

ISP Address: 2001:EE00:2575::/48

- Infrastructure Site ID: _____
- Sales Site ID: _____
- Accounting Site ID: _____
- Distribution Site ID: _____
- Casting Site ID: _____
- Editing Site ID: _____

Subnets Based on Location

ISP Address: 2001:EE00:2575::/48

- Infrastructure Site ID: _____
- Administration Site ID: _____
  - Infrastructure Sub-Site ID: _____
  - Sales Sub-Site ID: _____
  - Accounting Sub-Site ID: _____
  - Distribution Sub-Site ID: _____
- Production Site ID: _____
  - Infrastructure Sub-Site ID: _____
  - Casting Sub-Site ID: _____
  - Editing Sub-Site ID: _____

IPv6 Subnetting Problems

Subnetting on the Nibble Boundary

Problem 2

Using the minimum number of subnets required for the primary and secondary sites design two IPv6 address plans that meets the following requirements. Create one plan for user groups and a second plan for location.

A new medical supply company is opening and needs an IPv6 network plan developed. The company has three buildings and will include the following user groups:

The ISP has given the company 3F01:ABCD:8875::/48.

Building 1	Building 2	Building 3
Users Include:	Users Include:	Users Include:
Management	Management	Management
Sales	Human Resources	Warehouse

Subnets Based on User Groups

ISP Address: 3F01:ABCD:8875::/48

- Infastructure Site ID: _____
- Management Site ID: _____
- Sales Site ID: _____
- Human Resources Site ID: _____
- Warehouse Site ID: _____

Subnets Based on Location

ISP Address: 3F01:ABCD:8875::/48

- Infrastructure Site ID: _____
- Building 1 Site ID: _____
  - Infrastructure Sub-Site ID: _____
  - Management Sub-Site ID: _____
  - Sales Sub-Site ID: _____
- Building 2 Site ID: _____
  - Infrastructure Sub-Site ID: _____
  - Management Sub-Site ID: _____
  - Human Resources Sub-Site ID: _____
- Building 2 Site ID: _____
  - Infrastructure Sub-Site ID: _____
  - Management Sub-Site ID: _____
  - Warehouse Sub-Site ID: _____

IPv6 Subnetting Problems

Subnetting on the Nibble Boundary

Problem 3

Using the minimum number of subnets required for the primary and secondary sites design two IPv6 address plans that meets the following requirements. Create one plan for user groups and a second plan for location.

A paper supply company needs an IPv6 network plan developed. The company has two buildings and will include the following user groups and sub-user groups:

The ISP has given the company 2001:CA21:9000::/48.

Building A

Management Groups
Human Resources
Sales:
- Wholesale
- Retail

Building B

Production Groups
Warehouse
Shipping:
- Domestic
- Worldwide

Subnets Based on User Groups

ISP Address: 2001:CA21:9000::/48 (The ISP's Global Routing Prefix is already printed for you.)

- P Infrastructure Site ID: 2001:CA21:9000:
- P Management Groups Site ID: 2001:CA21:9000:
  - S1 HR Sub-Site ID: 2001:CA21:9000:
  - S1 Sales Sub-Site ID: 2001:CA21:9000:
    - S2 Wholesale Sub- Site ID: 2001:CA21:9000:
    - S2 Retail Sub- Site ID: 2001:CA21:9000:
- P Production Groups Site ID: 2001:CA21:9000:
  - S1 Warehouse Sub-Site ID: 2001:CA21:9000:
  - S1 Shipping Sub-Site ID: 2001:CA21:9000:
    - S2 Domestic Sub-Site ID: 2001:CA21:9000:
    - S2 Worldwide Sub-Site ID: 2001:CA21:9000:

Subnets Based on Location

ISP Address: 2001:CA21:9000::/48 (The ISP's Global Routing Prefix is already printed for you.)

- P Infrastructure Site ID: 2001:CA21:9000:
- P Building A Site ID: 2001:CA21:9000:
  - S1 Infrastructure Sub-Site ID: 2001:CA21:9000:
  - S1 HR Sub-Site ID: 2001:CA21:9000:
  - S1 Sales Sub-Site ID: 2001:CA21:9000:
    - S2 Wholesale Sub-Site ID: 2001:CA21:9000:
    - S2 Retail Sub-Site ID: 2001:CA21:9000:
- P Building B Site ID: 2001:CA21:9000:
  - S1 Infrastructure Sub-Site ID: 2001:CA21:9000:
  - S1 Warehouse Sub-Site ID: 2001:CA21:9000:
  - S1 Shipping Sub-Site ID: 2001:CA21:9000:
    - S2 Domestic Sub-Site ID: 2001:CA21:9000:
    - S2 Worldwide Sub-Site ID: 2001:CA21:9000:

IPv6 Subnetting Problems

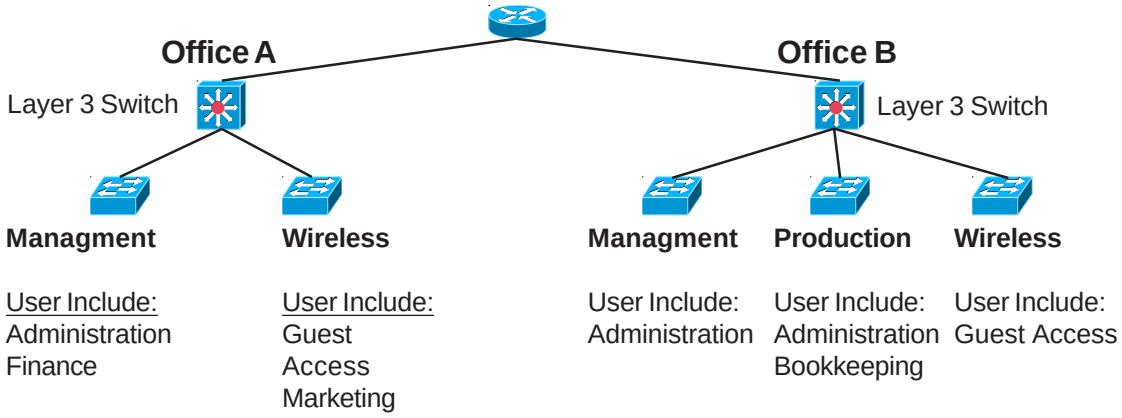
Subnetting on the Nibble Boundary

Problem 4

Using the minimum number of subnets required for the primary and secondary sites design two IPv6 address plans that meets the following requirements. Create one plan for location and the second plan for user groups.

A company is setting up a new server farm and needs an IPv6 network plan developed. The Core Router and the direct connections with layer 3 switches will pull their IPv6 addresses from the Infrastructure Site ID range.

The ISP has given the company 2000:ACAD:1145::/48.



Subnets Based on User Groups

- ISP Address: 2000:ACAD:1145::/48 (The ISP's Global Routing Prefix is already printed for you.)
- Infrastructure Site ID: 2000:ACAD:1145:
- Administration Site ID: 2000:ACAD:1145:
- Finance Site ID: 2000:ACAD:1145:
- Guest Access Site ID: 2000:ACAD:1145:
- Marketing Site ID: 2000:ACAD:1145:
- Bookkeeping Site ID: 2000:ACAD:1145:

Subnets Based on Location

ISP Address: 2000:ACAD:1145::/48 (The ISP's Global Routing Prefix is already printed for you.)

- P Infrastructure Site ID: 2000:ACAD:1145:
- P Office A Site ID: 2000:ACAD:1145:
  - S1 Infrastructure Sub-Site ID: 2000:ACAD:1145:
  - S1 Management Sub-Site ID: 2000:ACAD:1145:
    - S2 Administration Sub-Site ID: 2000:ACAD:1145:
    - S2 Finance Sub-Site ID: 2000:ACAD:1145:
  - S1 Wireless Access Sub-Site ID: 2000:ACAD:1145:
    - S2 Guest Access Sub-Site ID: 2000:ACAD:1145:
    - S2 Marketing Sub-Site ID: 2000:ACAD:1145:
- P Office B Site ID: 2000:ACAD:1145:
  - S1 Infrastructure Sub-Site ID: 2000:ACAD:1145:
  - S1 Management Sub-Site ID: 2000:ACAD:1145:
    - S2 Administration Sub-Site ID: 2000:ACAD:1145:
  - S1 Production Sub-Site ID: 2000:ACAD:1145:
    - S2 Administration Sub-Site ID: 2000:ACAD:1145:
    - S2 Bookkeeping Sub-Site ID: 2000:ACAD:1145:
  - S1 Wireless Access Sub-Site ID: 2000:ACAD:1145:
    - S2 Guest Access Sub-Site ID: 2000:ACAD:1145:

IPv6 Subnetting Problems

Subnetting on the Nibble Boundary

Problem 5

Using the minimum number of subnets required for the primary and secondary sites design two IPv6 address plans that meets the following requirements. Create one plan for user groups and a second plan for location.

The company has multiple floors in a high rise building and will include the following user groups and sub-user groups:

The ISP has given the company 3F01:AA07:3907::/48.

33rd Floor

Manufacturing Groups
Marketing
Inventory
Shipping

34th Floor

Admin Groups
Human Resources (HR):
- Hiring
- Benifits

Financial:
- Purchasing
- Sales

Subnets Based on User Groups

- ISP Address: 3F01:AA07:3907::/48 (The ISP's Global Routing Prefix is already printed for you.)
- Infrastructure Site ID: 3F01:AA07:3907:
- Manufacturing Groups Site ID: 3F01:AA07:3907:1
  - S1 Infrastructure Sub-Site ID: 3F01:AA07:3907:
  - S1 Marketing Sub-Site ID: 3F01:AA07:3907:
  - S1 Inventory Sub-Site ID: 3F01:AA07:3907:
  - S1 Shipping Sub- Site ID: 3F01:AA07:3907:
- Admin Groups Site ID: 3F01:AA07:3907:
  - S1 Infrastructure Sub-Site ID: 3F01:AA07:3907:
  - S1 HR Sub-Site ID: 3F01:AA07:3907:
    - S2 Hiring Sub-Site ID: 3F01:AA07:3907:
    - S2 Benfits Sub-Site ID: 3F01:AA07:3907:

- S1 Financial Sub-Site ID: 3F01:AA07:3907:
  - S2 Purchasing Sub-Site ID: 3F01:AA07:3907:
  - S2 Sales Sub-Site ID: 3F01:AA07:3907:

Subnets Based on Location

ISP Address: 3F01:AA07:3907::/48 (The ISP's Global Routing Prefix is already printed for you.)

- P Infrastructure Site ID: 3F01:AA07:3907:
- P 33rd Floor Site ID: 3F01:AA07:3907:
  - S1 Infrastructure Sub-Site ID: 3F01:AA07:3907:
  - S1 Manufacturing Groups Sub- Site ID: 3F01:AA07:3907:
    - S2 Marketing Sub-Site ID: 3F01:AA07:3907:
    - S2 Inventory Sub-Site ID: 3F01:AA07:3907:
    - S2 Shipping Sub- Site ID: 3F01:AA07:3907:
- P 34th Floor Site ID: 3F01:AA07:3907:
  - S1 Infrastructure Sub-Site ID: 3F01:AA07:3907:
  - S1 Admin Groups Sub-Site ID: 3F01:AA07:3907:
    - S2 HR Sub-Site ID: 3F01:AA07:3907:
      - S3 Hiring Sub-Site ID: 3F01:AA07:3907:
      - S3 Benefits Sub-Site ID: 3F01:AA07:3907:
    - S2 Financial Sub-Site ID: 3F01:AA07:3907:
      - S3 Purchasing Sub-Site ID: 3F01:AA07:3907:
      - S3 Sales Sub-SiteID: 3F01:AA07:3907:

IPv6 Subnetting Problems

Subnetting on the Nibble Boundary

Problem 6

Using the minimum number of subnets required for the primary and secondary sites design two IPv6 address plans that meets the following requirements. Create one plan for location and the second plan for user groups.

This medium sized company will include the following user groups and sub-user groups:

The ISP has given the company 2001:0:17::**/52**

Management	**Finance**	**Marketing Department**
Users Include:	Users Include:	Users Include:
Laboratory	Staff	Advertising:
Administrators		Radio
Staff		TV
		Web
		Sales:
		Retail
		Wholesale

Subnets Based on User Groups

- ISP Address: 2001:0:17::**/52** (The ISP's Global Routing Prefix is already printed for you.)
- Infrastructure Site ID: 2001:0:17:
- Administrators Site ID: 2001:0:17:
- Staff Site ID: 2001:0:17:
- Advertising Site ID: 2001:0:17:
  - Infrastructure Sub-Site ID: 2001:0:17:
  - Radio Sub-Site ID: 2001:0:17:
  - TV Sub- Site ID: 2001:0:17:
  - Web Sub- Site ID: 2001:0:17:
- Sales Site ID: 2001:0:17:
  - Infrastructure Sub-Site ID: 2001:0:17:
  - Retail Sub-Site ID: 2001:0:17:
  - Wholesale Sub-Site ID: 2001:0:17:

Subnets Based on Location

- ISP Address: 2001:0:17::**/52** (The ISP's Global Routing Prefix is already printed for you.)
- Infrastructure Site ID: 2001:0:17:
- Management Site ID: 2001:0:17:
  - Infrastructure Sub-Site ID: 2001:0:17:
  - Administrators Sub-Site ID: 2001:0:17:
  - Staff Sub- Site ID: 2001:0:17:
- Finance Site ID: 2001:0:17:
  - Infrastructure Sub-Site ID: 2001:0:17:
  - Staff Sub-Site ID: 2001:0:17:
- Marketing Dept Site ID: 2001:0:17:
  - Infrastructure Sub-Site ID: 2001:0:17:
  - Advertising Sub-Site ID: 2001:0:17:
    - Radio Sub-Site ID: 2001:0:17:
    - TV Sub-Site ID: 2001:0:17:
    - Web Sub-Site ID: 2001:0:17:
  - Sales Sub-Site ID: 2001:0:17:
    - Retail Sub-Site ID: 2001:0:17:
    - Wholesale Sub-Site ID: 2001:0:17:

IPv6 Subnetting Problems
Subnetting on the Nibble Boundary

Problem 7

Using the minimum number of subnets required for the primary and secondary sites design two IPv6 address plans that meets the following requirements. Create one plan for location and the second plan for user groups.

This medium sized company is setting up a new IPv6 addressing plan which will include the following user groups and sub-user groups:

The ISP has given the company 3F00:3589:0:5000:***/52***

Office A	**Office B**	**Office C**
Users Include:	Users Include:	Users Include:
Management	Management	Management
Human Relations (HR):	Finance:	Purchasing:
Record Keeping	Sales	Inventory
Insurance		Distribution

Subnets Based on User Groups

ISP Address: 3F00:3589:0:5000:***/52*** (The ISP's Global Routing Prefix is already printed for you.)

- Infrastructure Site ID: 3F00:3589:0:
- Management Site ID: 3F00:3589:0:
- HR Site ID: 3F00:3589:0:
  - Infrastructure Sub-Site ID: 3F00:3589:0:
  - Record Keeping Sub-Site ID: 3F00:3589:0:
  - Insurance Site ID: 3F00:3589:0:
- Finance Site ID: 3F00:3589:0:
  - Infrastructure Sub-Site ID: 3F00:3589:0:
  - Sales Sub-Site ID: 3F00:3589:0:
- Purchasing Sub-Site ID: 3F00:3589:0:
  - Inventory Sub-Site ID: 3F00:3589:0:
  - Distribution Sub-Site ID: 3F00:3589:0:

Subnets Based on Location

ISP Address: 3F00:3589:0:5000:***/52*** (The ISP's Global Routing Prefix is already printed for you.)

- P Infrastructure Site ID: 3F00:3589:0:
- P Office A Site ID: 3F00:3589:0:
  - S1 Infrastructure Sub-Site ID: 3F00:3589:0:
  - S1 Management Sub-Site ID: 3F00:3589:0:
  - S1 HR Sub- Site ID: 3F00:3589:0:
    - S2 Record Keeping Sub-Site ID: 3F00:3589:0:
    - S2 Insurance Sub-Site ID: 3F00:3589:0:
- P Office B Site ID: 3F00:3589:0:
  - S1 Infrastructure Sub-Site ID: 3F00:3589:0:
  - S1 Management Sub-Site ID: 3F00:3589:0:
  - S1 Finance Sub-Site ID: 3F00:3589:0:
    - S2 Sales Sub-Site ID: 3F00:3589:0:
- P Office C Site ID: 3F00:3589:0:
  - S1 Infrastructure Sub-Site ID: 3F00:3589:0:
  - S1 Management Sub-Site ID: 3F00:3589:0:
  - S1 Purchasing Sub-Site ID: 3F00:3589:0:
    - S2 Inventory Sub-Site ID: 3F00:3589:0:
    - S2 Distribution Sub-Site ID: 3F00:3589:0:

IPv6 Subnetting Problems

Subnetting on the Nibble Boundary

Problem 8

Using the minimum number of subnets required for the primary and secondary sites design two IPv6 address plans that meets the following requirements. Create one plan for location and the second plan for user groups.

A Health Care facility is upgrading their network to IPv6 and will include the following user groups and sub-user groups:

The ISP has given the company 2000:2531:FE00::/48.

Emergency	Admissions	Patient Wards
Users Include:	Users Include:	Users Include:
Nurses/Staff	Nurses/Staff	Ward A:
Laboratory	Records	Nurses/Staff
Obstetrics		Guest WIFI
Pediactric		Ward B:
		Nurses/Staff
		Guest WIFI

Subnets Based on User Groups

ISP Address: 2000:2531:FE00::/48 (The ISP's Global Routing Prefix is already printed for you.)

- Infrastructure Site ID: 2000:2531:FE00:
- Nurses/Staff Site ID: 2000:2531:FE00:
- Laboratory Site ID: 2000:2531:FE00:
- Obstetrics Site ID: 2000:2531:FE00:
- Pediatric Site ID: 2000:2531:FE00:
- Records Site ID: 2000:2531:FE00:
- Guest WIFI Site ID: 2000:2531:FE00:

Subnets Based on Location

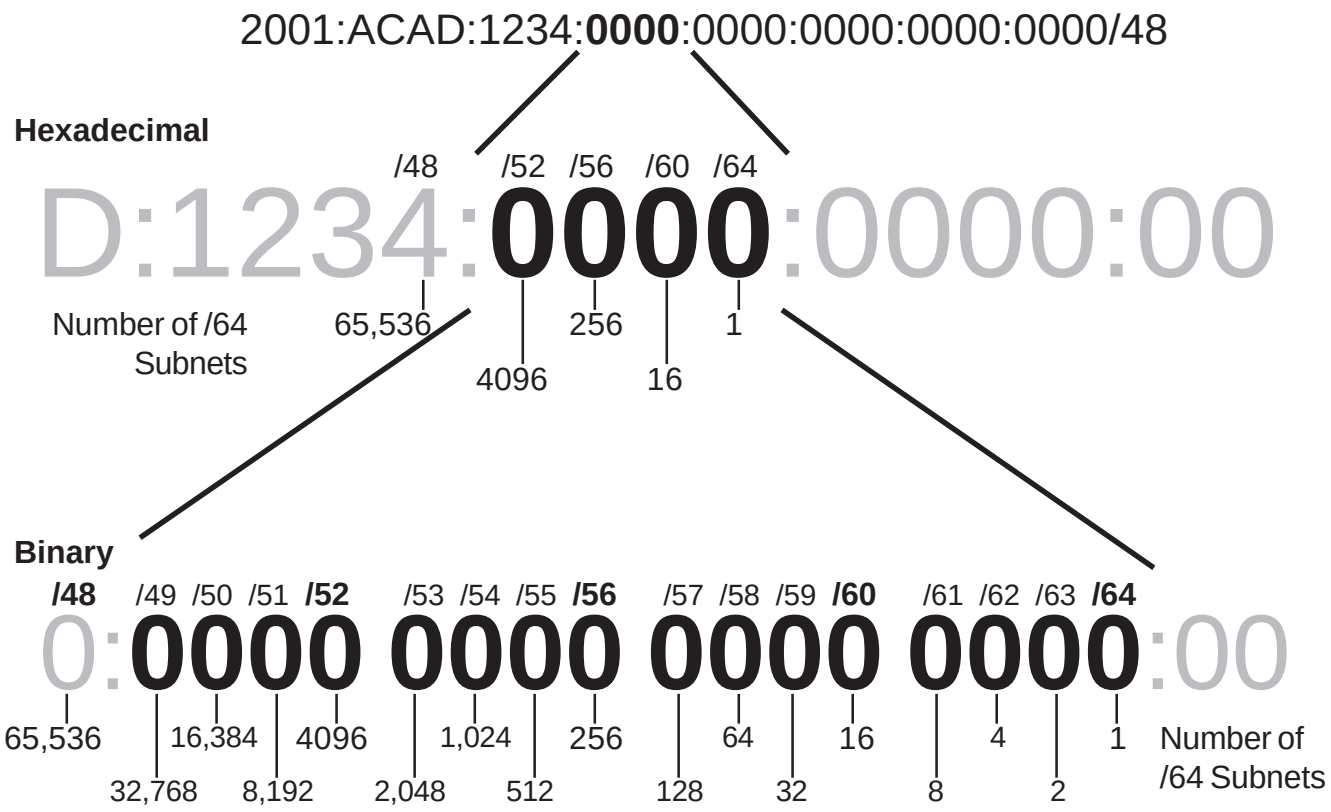
ISP Address: 2000:2531:FE00::/48 (The ISP's Global Routing Prefix is already printed for you.)

- P Infrastructure Site ID: 2000:2531:FE00:
- P Emergency Site ID: 2000:2531:FE00:
  - S1 Infrastructure Sub-Site ID: 2000:2531:FE00:
  - S1 Nurses/Staff Sub-Site ID: 2000:2531:FE00:
  - S1 Laboratory Sub-Site ID: 2000:2531:FE00:
  - S1 Obstetrics Sub-Site ID: 2000:2531:FE00:
  - S1 Pediatric Sub-Site ID: 2000:2531:FE00:
- P Admissions Site ID: 2000:2531:FE00:
  - S1 Infrastructure Sub-Site ID: 2000:2531:FE00:
  - S1 Nurses/Staff Sub-Site ID: 2000:2531:FE00:
  - S1 Records Sub-Site ID: 2000:2531:FE00:
- P Patient Wards Site ID: 2000:2531:FE00:
  - S1 Infrastructure Sub-Site ID: 2000:2531:FE00:
  - S1 Ward A Sub-Site ID: 2000:2531:FE00:
    - S2 Nurses/Staff Sub-Site ID: 2000:2531:FE00:
    - S2 Guest WIFI Sub-Site ID: 2000:2531:FE00:
  - S1 Ward B Sub-Site ID: 2000:2531:FE00:
    - S2 Nurses/Staff Sub-Site ID: 2000:2531:FE00:
    - S2 Guest WIFI Sub-Site ID: 2000:2531:FE00:

Subnetting Within a Nibble

It is a Best Practice to subnet on the Nibble Boundary. However, subnetting within a Nibble is an acceptable practice. It tends to make subnetting, implementation, and troubleshooting more difficult.

Subnet ID Break Down

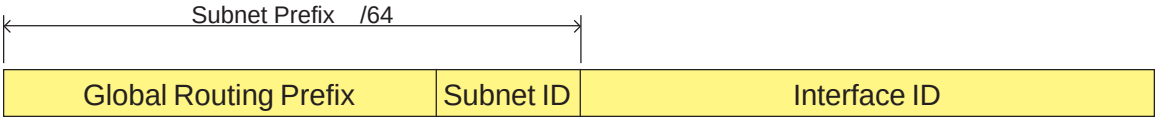


Subnetting Beyond the /64 Boundary

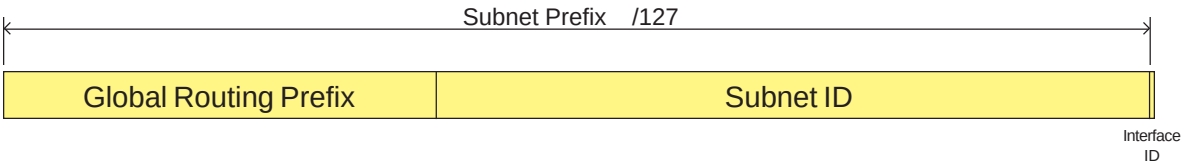
What happens if you need more subnets than the 16 bit Subnet Prefix will allow? Or your IPv4 address conservatism kicks in and you decide that using a /64 Global Routing Prefix with over 18 quintillion addresses for a single point-to-point serial connection is more than you can handle; there are some options.

IPv6 was designed to be very flexible. The Subnet Prefix is the address space used by the Global Routing Prefix and the Subnet ID, and can range from 0 to 128.

Standard /48 Subnet Prefix



Point-To-Point /127 Subnet Prefix



Just as you could borrow host bits in IPv4, you can borrow Interface ID bits in IPv6. This allows you to create more subnets with fewer addresses. Before you get too excited, there are a few rules and best practices you need to take into account.

Borrowing bits from the Interface ID should only be done on network infrastructure links. Loopback addresses, point-to-point links, addresses that are usually statically assigned.

Any subnet that includes end devices needs to stay on a /64 or lower prefix. This would be computers, tablets, smart phones, servers, printers, anything that might be on a subnet that connects to the internet.

According to RFC 5375, a /64 prefix is required to support a number of benefits offered by IPv6; such as:

Stateless Address Autoconfiguration
Neighbor Discovery (ND)
Secure Neighborship Discovery (SEND)
privacy extensions
parts of Mobile IPv6
PIM-SM with Embedded-RP
SHIM6 [SHIM6]
Plus a number of other features currently in development, or being proposed, which will rely on a /64 prefix.

The bottom line is that IPv6 was designed to waste an unbelievable amount of addresses and it's OK. So while it is possible to subnet beyond the /64 subnet prefix it is not recommended.

Define the Following IPv6 Terms:

(Use the definitions/explanations from this workbook)

1. Global Routing Prefix -

2. Subnet ID -

3. Interface ID -

4. Subnet Prefix -

5. Nibble -

6. Unspecified address -

7. Loopback address -

8. Ipv4 Embedded address -

9. Global Unicast address -

10. Unique Local address -

11. Multicast address -

12. Unicast address -

13. Multicast address -

14. Anycast address -

15. Site ID -

16. Sub-Site ID -

17. Prefix Length -

What Type of IPv6 Address is this?

Base on the information supplied on the inside front cover of this workbook identify the following IPv6 addresses as either: Unspecified, Loopback, Embedded IPv4, Global Unicast, Unique local Unicast, Link-local Unicast, or Multicast.

1. 2000:ACAD:1234::/48 Global Unicast

2. 0000:0000:0000:0000:0000:0000:0000:0000 Unspecified

3. FE80:ACAD:1234::\48 _____

4. FDFF:8771:3321::\48 _____

5. FFCD:984:1\48 _____

6. 3F98::\48 _____

7. ::1 _____

9. 3000::0001\64 _____

10. FEA1:8934:3021:8945:1234:ACAD:FE23:0001/64 _____

11. 00AB:2307:4829::\56 _____

13. FF45:6543:ACAD::\60 _____

14. 2ABC:ACAD:AAAA:0000:0000:0000:0000:00001\64 _____

15. FC12:0000:ACAD:1234:5678:9101:1121:3141/48 _____

16. 2345:FE66:FECD:9999:2365::1\52 _____

17. :: _____

18. 0000:0000:0000:0000:0000:0000:0000:0001 _____

19. FFF8:0000:00001::0023\64 _____

20. 0023:5935:F441::\48 _____

22. 2001:ABCD:1234:FFFF:ACAD::45\60 _____

23. 3211:FCAB:EEEE::\48 _____

24. FCCC:25:1::\48 _____

Reference Section

IANA IPv6 Gloabal Unicast Address Alocations to the RIRs

Prefix	Designation	Date	Whois	Status
2001:0000::/23	IANA	7/1/1999	whois.iana.org	ALLOCATED
2001:0200::/23	APNIC	7/1/1999	whois.apnic.net	ALLOCATED
2001:0400::/23	ARIN	7/1/1999	whois.arin.net	ALLOCATED
2001:0600::/23	RIPE NCC	7/1/1999	whois.ripe.net	ALLOCATED
2001:0800::/23	RIPE NCC	5/2/2002	whois.ripe.net	ALLOCATED
2001:0a00::/23	RIPE NCC	11/2/2002	whois.ripe.net	ALLOCATED
2001:0c00::/23	APNIC	5/2/2002	whois.apnic.net	ALLOCATED
2001:0e00::/23	APNIC	1/1/2003	whois.apnic.net	ALLOCATED
2001:1200::/23	LACNIC	11/1/2002	whois.lacnic.net	ALLOCATED
2001:1400::/23	RIPE NCC	2/1/2003	whois.ripe.net	ALLOCATED
2001:1600::/23	RIPE NCC	7/1/2003	whois.ripe.net	ALLOCATED
2001:1800::/23	ARIN	4/1/2003	whois.arin.net	ALLOCATED
2001:1a00::/23	RIPE NCC	1/1/2004	whois.ripe.net	ALLOCATED
2001:1c00::/22	RIPE NCC	5/4/2001	whois.ripe.net	ALLOCATED
2001:2000::/20	RIPE NCC	5/4/2001	whois.ripe.net	ALLOCATED
2001:3000::/21	RIPE NCC	5/4/2001	whois.ripe.net	ALLOCATED
2001:3800::/22	RIPE NCC	5/4/2001	whois.ripe.net	ALLOCATED
2001:3c00::/22	IANA			RESERVED
2001:4000::/23	RIPE NCC	6/11/2004	whois.ripe.net	ALLOCATED
2001:4200::/23	AFRINIC	6/1/2004	whois.afrinic.net	ALLOCATED
2001:4400::/23	APNIC	6/11/2004	whois.apnic.net	ALLOCATED
2001:4600::/23	RIPE NCC	8/17/2004	whois.ripe.net	ALLOCATED
2001:4800::/23	ARIN	8/24/2004	whois.arin.net	ALLOCATED
2001:4a00::/23	RIPE NCC	10/15/2004	whois.ripe.net	ALLOCATED
2001:4c00::/23	RIPE NCC	12/17/2004	whois.ripe.net	ALLOCATED
2001:5000::/20	RIPE NCC	9/10/2004	whois.ripe.net	ALLOCATED
2001:8000::/19	APNIC	11/30/2004	whois.apnic.net	ALLOCATED
2001:a000::/20	APNIC	11/30/2004	whois.apnic.net	ALLOCATED
2001:b000::/20	APNIC	3/8/2006	whois.apnic.net	ALLOCATED
2002:0000::/16	6to4	2/1/2001		ALLOCATED
2003:0000::/18	RIPE NCC	1/12/2005	whois.ripe.net	ALLOCATED
2400:0000::/12	APNIC	10/3/2006	whois.apnic.net	ALLOCATED
2600:0000::/12	ARIN	10/3/2006	whois.arin.net	ALLOCATED
2610:0000::/23	ARIN	11/17/2005	whois.arin.net	ALLOCATED
2620:0000::/23	ARIN	9/12/2006	whois.arin.net	ALLOCATED
2800:0000::/12	LACNIC	10/3/2006	whois.lacnic.net	ALLOCATED
2a00:0000::/12	RIPE NCC	10/3/2006	whois.ripe.net	ALLOCATED
2c00:0000::/12	AFRINIC	10/3/2006	whois.afrinic.net	ALLOCATED
2d00:0000::/8	IANA	7/1/1999		RESERVED
2e00:0000::/7	IANA	7/1/1999		RESERVED
3000:0000::/4	IANA	7/1/1999		RESERVED
3ffe::/16	IANA	2008-04		RESERVED
5f00::/8	IANA	2008-04		RESERVED

Prefix-Length	Number of IPs
/128	1
/127	2
/126	4
/125	8
/124	16
/123	32
/122	64
/121	128
/120	256
/119	512
/118	1,024
/117	2,048
/116	4,096
/115	8,192
/114	16,384
/113	32,768
/112	65,536
/111	131,072
/110	262,144
/109	524,288
/108	1,048,576
/107	2,097,152
/106	4,194,304
/105	8,388,608
/104	16,777,216
/103	33,554,432
/102	67,108,864
/101	134,217,728
/100	268,435,456
/99	536,870,912
/98	1,073,741,824
/97	2,147,483,648
/96	4,294,967,296
/95	8,589,934,592
/94	17,179,869,184
/93	34,359,738,368
/92	68,719,476,736
/91	137,438,953,472
/90	274,877,906,944
/89	549,755,813,888
/88	1,099,511,627,776
/87	2,199,023,255,552
/86	4,398,046,511,104
/85	8,796,093,022,208
/84	17,592,186,044,416
/83	35,184,372,088,832
/82	70,368,744,177,664
/81	140,737,488,355,328
/80	281,474,976,710,656
/79	562,949,953,421,312
/78	1,125,899,906,842,620
/77	2,251,799,813,685,240
/76	4,503,599,627,370,490
/75	9,007,199,254,740,990
/74	18,014,398,509,481,900
/73	36,028,797,018,963,900
/72	72,057,594,037,927,900
/71	144,115,188,075,855,000
/70	288,230,376,151,711,000
/69	576,460,752,303,423,000
/68	1,152,921,504,606,840,000
/67	2,305,843,009,213,690,000
/66	4,611,686,018,427,380,000
/65	9,223,372,036,854,770,000
/64 - Residential	18,446,744,073,709,500,000
/63	36,893,488,147,419,100,000
/62	73,786,976,294,838,200,000
/61	147,573,952,589,676,000,000
/60 - Residential	295,147,905,179,352,000,000
/59	590,295,810,358,705,000,000
/58	1,180,591,620,717,410,000,000
/57	2,361,183,241,434,820,000,000
/56 - Medium	4,722,366,482,869,640,000,000
/55	9,444,732,965,739,290,000,000
/54	18,889,465,931,478,500,000,000
/53	37,778,931,862,957,100,000,000
/52	75,557,863,725,914,300,000,000
/51	151,115,727,451,828,000,000,000
/50	302,231,454,903,657,000,000,000
/49	604,462,909,807,314,000,000,000
/48 - Large	1,208,925,819,614,620,000,000,000
/47	2,417,851,639,229,250,000,000,000
/46	4,835,703,278,458,510,000,000,000
/45	9,671,406,556,917,030,000,000,000
/44	19,342,813,113,834,000,000,000,000
/43	38,685,626,227,668,100,000,000,000
/42	77,371,252,455,336,200,000,000,000
/41	154,742,504,910,672,000,000,000,000
/40	309,485,009,821,345,000,000,000,000
/39	618,970,019,642,690,000,000,000,000
/38	1,237,940,039,285,380,000,000,000,000
/37	2,475,880,078,570,760,000,000,000,000
/36	4,951,760,157,141,520,000,000,000,000
/35	9,903,520,314,283,040,000,000,000,000
/34	19,807,040,628,566,000,000,000,000,000
/33	39,614,081,257,132,100,000,000,000,000
/32 - Service LIR	79,228,162,514,264,300,000,000,000,000
/31	158,456,325,028,528,000,000,000,000,000
/30	316,912,650,057,057,000,000,000,000,000
/29	633,825,300,114,114,000,000,000,000,000
/28	1,267,650,600,228,220,000,000,000,000,000
/27	2,535,301,200,456,450,000,000,000,000,000
/26	5,070,602,400,912,910,000,000,000,000,000
/25	10,141,204,801,825,800,000,000,000,000,000
/24	20,282,409,603,651,600,000,000,000,000,000
/23 - ISP	40,564,819,207,303,300,000,000,000,000,000
/22	81,129,638,414,606,600,000,000,000,000,000
/21	162,259,276,829,213,000,000,000,000,000,000
/20	324,518,553,658,426,000,000,000,000,000,000
/19	649,037,107,316,853,000,000,000,000,000,000
/18	1,298,074,214,633,700,000,000,000,000,000,000
/17	2,596,148,429,267,410,000,000,000,000,000,000
/16	5,192,296,858,534,820,000,000,000,000,000,000
/15	10,384,593,717,069,600,000,000,000,000,000,000
/14	20,769,187,434,139,300,000,000,000,000,000,000
/13	41,538,374,868,278,600,000,000,000,000,000,000
/12	83,076,749,736,557,200,000,000,000,000,000,000
/11	166,153,499,473,114,000,000,000,000,000,000,000
/10	332,306,998,946,228,000,000,000,000,000,000,000
/9	664,613,997,892,457,000,000,000,000,000,000,000
/8	1,329,227,995,784,910,000,000,000,000,000,000,000

IPv6 Resources

Web Sites:

ARIN IPv6 Wiki
http://www.getipv6.info/display/IPv6/IPv6+Info+Home

Cisco Support Community IPv6 Subnetting - Overview and Case Study
https://supportforums.cisco.com/docs/DOC-17232

Videos:

IPv6 for CCNAs with Anthony Sequeira
Video Series by the Cisco Learning Network - Parts 1, 2 & 3
https://learningnetwork.cisco.com/docs/DOC-20357

PDF Resources:

Preparing An IPv6 Address Plan, Version 2, 18 September 2013
https://www.ripe.net/lir-services/training/material/IPv6-for-LIRs-Training-Course/IPv6_addr_plan4.pdf

Best Current Operational Practices - IPv6 Subnetting (v1)
http://www.ipbcop.org/wp-content/uploads/2012/02/BCOP-IPv6_Subnetting.pdf

6net An IPv6 Deployment Guide by The European 6NET Consortium
http://www.6net.org/book/deployment-guide.pdf

IPv6 Addressing At-A-Glance By Cisco
http://www.cisco.com/en/US/technologies/tk648/tk872/technologies_white_paper0900aecd8026003d.pdf

IPv6 Implementation Guide, Cisco IOS Release 15.2M&T
http://www.cisco.com/en/US/docs/ios-xml/ios/ipv6/configuration/15-2mt/ipv6-15-2mt-book.pdf

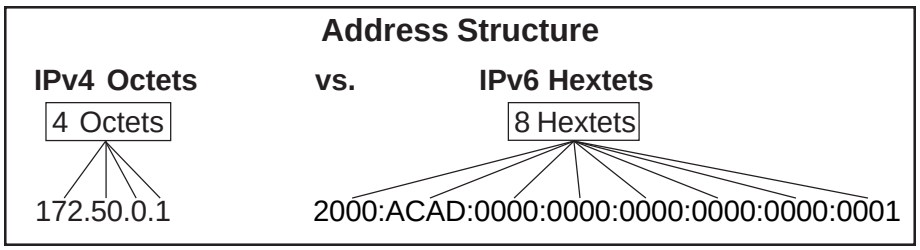
Printed Books:

IPv6 Fundamentals A Straightforward Approach to Understanding IPv6
By Rick Graziani
ISBN-13: 978-1-58714-313-7

Understanding IPv6 Third Edition
By Joseph Davies
ISBN: 978-0-7356-5914-8

Avalible subnets within the Subnet ID using the Nibble boundary.

/48 No Nibbles	/52 1 Nibble	/56 2 Nibbles	/60 3 Nibbles	/64 4 Nibbles
/48 - 1 Subnet				
/52 - 16 Subnets	/52 - 1 Subnet			
/56 - 256 Subnets	/56 - 16 Subnets	/56 - 1 Subnets		
/60 - 4096 Subnets	/60 - 256 Subnets	/60 - 16 Subnets	/60 - 1 Subnets	
/64 - 65,536 Subnets	/64 - 4096 Subnets	/64 - 256 Subnets	/64 - 16 Subnets	/64 - 1 Subnet



What is a Site?
A Site = one building
A home, apartment, or house = a Site
A campus with 10 buildings = 10 Sites
A single building with 15 businesses = 15 Sites

Conversion Chart

Decimal (Base 10)	Hexadecimal (Base 16)	Binary (Base 2)
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
10	A	1010
11	B	1011
12	C	1100
13	D	1101
14	E	1110
15	F	1111