ITFreeTraining

| 2001:db8:cad:4000::/56 | 2001:db8:cad:4100::/56 | 2001:db8:cad:4200::/56 |

Allocate Third Level To Offices
At most 10 offices per region

| Powers of 2	2^1	2^2	2^3	2^4	2^5	2^6	2^7	2^8	2^9	2^{10}	2^{11}	2^{12}	2^{13}	2^{14}	2^{15}	2^{16}
Number of networks	2	4	8	16	32	64	128	256	512	1024	2048	4096	8192	16384	32769	65536

IPv6 Subnetting

For the free video please see
http://itfreetraining.com/ipv6/subnetting-manually

This video will look at how to subnet IPv6 addresses without the use of online subnetting tools. By using the Windows calculator, this video will show you how to quickly and easily perform subnetting with IPv6 addresses. This will allow you to implement IPv6 subnetting in your organization.

IPv6 Subnetting Example

48 Bits	16 Bits	64 Bits
`2001:db8:cad`	**Subnet ID**	`Interface ID`

f = fixed   r = remaining
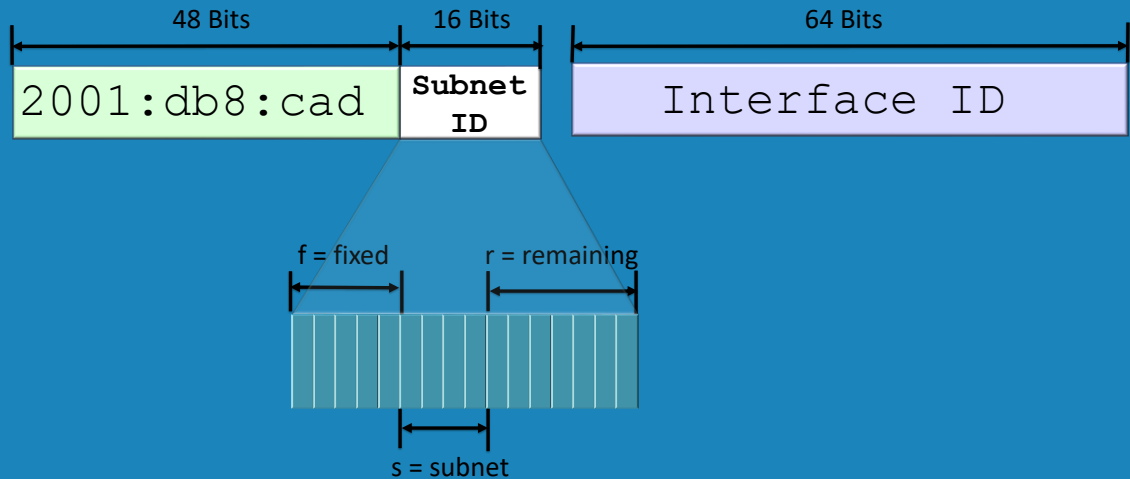
s = subnet

- f + s + r = 16 (Always adds up to 16)

0:21 In this example, the ISP has allocated an address of 2001:db8:cad to the end user. This leaves 16 bits of the subnet ID that can be allocated by the customer. In some cases, an ISP may not allocate the full 16 bits to the customer. They may choose to allocate a smaller amount if the IP Address has been divided up between different ISP customers. The last part of the address is the 64-bit interface ID. This is irrelevant for subnetting so the video will only focus on the subnet ID.

1:18 The subnet ID is made up of 16 bits. When the administrator is given an IPv6 address to break into different subnets, some of the subnet ID may have already been used. This may be in use by the ISP or the company has already allocated some of the subnet ID. Part of the maths that is used in this video is the formula f + S + r = 16. The different letters stand for the following: F = This is the number of bits of the subnet ID that have already been allocated. Some may have been allocated by the ISP or have been allocated to other networks.
S = This is the number of bits that the administrator wants to allocate to the next level of subnetting. For example, if the administrator wanted to add 8 networks, then 3 bits would need to be allocated from the subnet ID.
R = This is the remaining bits that have not been allocated. The administrator is free to allocate these remaining bits later on if they require them. For example, creating another level of networks in the hierarchy.
• f + s + r = 16 (Always adds up to 16. If the result is something else, check to see if a mistake has been made)

Subnet of Different Countries

- 2 to the power of 2 gives a total of 4 networks

Powers of 2	2^1	2^2	2^3	2^4	2^5	2^6	2^7	2^8	2^9	2^{10}	2^{11}	2^{12}	2^{13}	2^{14}	2^{15}	2^{16}
Number of networks	2	4	8	16	32	64	128	256	512	1024	2048	4096	8192	16384	32768	65536

3:06 In this example, the subnet ID will be broken down into 3 different networks; America, Canada and England. This means 3 different networks are required. To determine how many bits of the subnet ID are required, the powers of 2 table is used. Looking at this, 2 bits are required which will give 4 networks. When looking at the powers of 2 table, you need to have the same number of networks or greater in order to determine how many bits are required. For example, 1 bit would not be enough because 1 bit would only give 2 networks whereas 3 are required. 2 bits gives 4 networks meaning that one network will not get used. However, this does give the administrator the ability to add another country later on if required.

Breakdown for First Subnet Level

48 Bits f = 0 r = 14

`2001:db8:cad::/48` Subnet ID

S = 2
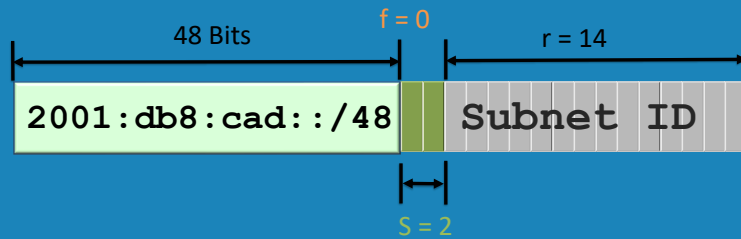
Incremental value for next subnet ID

$i = 2^{16-f-s}$

$i = 2^{16-0-2}$

$i = 2^{14}$

$i = 16384 \ 0x4000$

First Level Subnets

`2001:db8:cad:0000::/50`

`2001:db8:cad:4000::/50`

`2001:db8:cad:8000::/50`

`2001:db8:cad:c000::/50`

4:04 IPv6 supports a hierarchy of networks. The first subnets are referred to as the first level subnets. In order to calculate each subnet, an increment value needs to be determined. This value is what needs to be added to the last network in order to determine the next network. To do this the formula 2 to the power of (16-f-s) is used. In this example f = 0 and s = 2. This results in 2 to the power of 14. The Windows calculator can be used to work out this value. The Windows calculator has different functions depending on which mode it is in. To access x to the power y, the Windows calculator needs to be in scientific mode. Scientific mode shows that 2 to the power of 14 is 16,384. IPv6 address are in hexadecimal so it is best to change to this to hexadecimal. To do this, change the mode to programmer, enter the number and then press the hex button. In this example, the hexadecimal value is 0x4000. The next step is to work out the subnets. The first subnet will be the same as the original subnet, however the network prefix will change. In this example, /48 will change to /50. For the next subnet you add the increment value giving a value of 4000. The next subnet will be 8000 and the last subnet will be c0000. The process is very simple to do once you know the increment value.

Allocate to Different Countries

2001:db8:cad:0000::/50	2001:db8:cad:4000::/50	2001:db8:cad:8000::/50

Allocate Second Level to State/Provinces/Territories
At the most 60

Powers of 2	2^1	2^2	2^3	2^4	2^5	2^6	2^7	2^8	2^9	2^{10}	2^{11}	2^{12}	2^{13}	2^{14}	2^{15}	2^{16}
Number of networks	2	4	8	16	32	64	128	256	512	1024	2048	4096	8192	16384	32768	65536

07:41 Since the different networks have been worked out, they can now be allocated to different countries. In this example they will be allocated as follows:
USA: 2001:db8:cad:0000::/50
Canada: 2001:db8:cad:4000::/50
England: 2001:db8:cad:8000::/50
For each country, networks will be allocated to different states/provinces/territories. No country has more than 60 of these so the powers of 2 table is consulted to work out how many bits this would require. In this case, 60 would require 6 bits. This gives 64 networks which mean that there are 4 free networks if further expansion requires them.

Breakdown for Second Subnet level

48 Bits   f = 2   r = 8

`2001:db8:cad:4000::/50` Subnet ID

S = 6
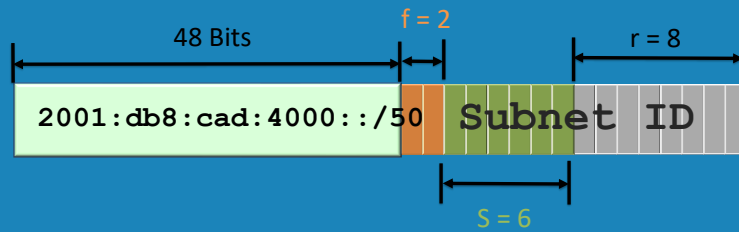
Incremental value for next subnet ID

$i = 2^{16-f-s}$

$i = 2^{16-2-6}$

$i = 2^{16-8}$

$i = 2^{8}$

$i = 256\ 0x100$

Second Level Subnets

`2001:db8:cad:4000::/56`

`2001:db8:cad:4100::/56`

`2001:db8:cad:4200::/56`

…

`2001:db8:cad:7f00::/56`

9:09 In this example, the network address for Canada will be broken down into smaller networks. Each network will be assigned to a different state. The first network is a copy of the network assigned to Canada, however the network prefix has changed from 50 to 56. The second network requires the increment value to be worked out. In this example, 2 bits have been allocated already so f = 2. Further to this, 6 more bits will need to be allocated. This means S = 6. This will require 2 to be raised to the power of 8. This will give a value of 256 which is 0x100 in hexadecimal. It is a simple matter to add this increment value to the address to work out the networks.

Allocate to Offices

2001:db8:cad:4000::/56	2001:db8:cad:4100::/56	2001:db8:cad:4200::/56

Allocate Third Level to Offices
At most 10 offices per region

Powers of 2	2^1	2^2	2^3	2^4	2^5	2^6	2^7	2^8	2^9	2^{10}	2^{11}	2^{12}	2^{13}	2^{14}	2^{15}	2^{16}
Number of networks	2	4	8	16	32	64	128	256	512	1024	2048	4096	8192	16384	32768	65536

11:44 The next step is to allocate a network to each state and work out how many bits will be used for offices in each state. In this example, the 3 network addresses have been allocated to different states in Canada. A third break down will be done for the offices in that state. There will be no more than 10 offices in each state, so looking at the power of 2 tables means that 4 bits will need to be used.

Breakdown for Third Subnet level

48 Bits   f = 8   r = 4

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2001:db8:cad:4100::/56
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S = 4
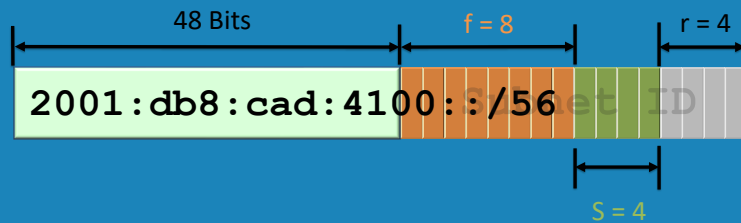
Incremental value for next subnet ID

$i = 2^{16-f-s}$

$i = 2^{16-8-4}$

$i = 2^{16-12}$

$i = 2^{4}$

$i = 16 \; 0x10$

Third Level Subnets

2001:db8:cad:4100::/60

2001:db8:cad:4110::/60

2001:db8:cad:4120::/60

…

2001:db8:cad:41f0::/60

12:08 In this example, 8 bits have been used in the subnet ID making the network prefix 56. To add the office network 4 bits will be used. This leaves 4 bits unallocated. If you have bits left over, it is worth considering using these on other networks. In this example, only 4 networks for different countries is supported. Adding one extra bit would mean that 8 countries would be supported. If you decided you need to add more countries later on and you have not left enough space, then every address on the network would need to change to add more countries. For this reason, if you have some spare bits, it is worth considering using them. Having the extra bits also means an additional level of subnetting can be allocated if required.

To work out the incremental value in this example, f=8 and s = 4. This will give 2 to the power of 4 which is 16 or 0x10 in hexadecimal. The next step is to work out the subnets. This is a matter of adding the increment value to the first network. This will give the following networks:
2001:db8:cad:4100::/60
2001:db8:cad:4110::/60
2001:db8:cad:4120::/60
2001:db8:cad:4130::/60
….
2001:db8:cad:41f0::/60

See http://YouTube.com/ITFreeTraining or http://itfreetraining.com for our always free training videos. This is only one video from the many free courses available on YouTube.

References
"Installing and Configuring Windows Server 2012 R2 Exam Ref 70-410" pages 210-211
"IPv6 Addressing (TechRef)" https://technet.microsoft.com/en-us/library/dd392266(v=ws.10).aspx

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