Classless Subnetting Explained

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When given an IP Address, Major Network Mask, and a Subnet Mask, how can you determine other information such as:

- The subnet address of this subnet
- The broadcast address of this subnet
- The range of Host Addresses for this subnet
- The maximum number of subnets for this subnet mask
- The number of hosts for each subnet
- The number of subnet bits
- The number of this subnet

Let's start with an example:

Host IP Address	**138.101.114.250**
Major Network Mask	**255.255.0.0 (/16)**
Major (Base) Network Address	
Major Network Broadcast Address	
Total Number of Host Bits Number of Hosts	
Subnet Mask	**255.255.255.192 (/26)**
Number of Subnet Bits Number of Usable Subnets (all 0's used, all 1's not used)	
Number of Host Bits per Subnet Number of Usable Hosts per Subnet	
Subnet Address for this IP Address	
IP Address of First Host on this Subnet	
IP Address of Last Host on this Subnet	
Broadcast Address for this Subnet	

Part 1: Determine Major Network Information

Before we begin subnetting, let's gather some information regarding the network in general,. Using the Major Network Mask, determine the major network Address, the broadcast address for the entire network, and the number of hosts for the entire network.

IP Address	138.101.114.250
Major Network Mask	255.255.0.0

Step 1: Translate Host IP Address and Major Network Mask into binary notation

Convert the Host IP Address and Major Network Mask to binary:

	138.	**101.**	**114.**	**250**
IP Address	10001010	01100101	01110010	11111010
Major Mask	11111111	11111111	00000000	00000000
	255.	**255.**	**0.**	**0**

Step 2: Major Network Address

1. Draw a line under the major mask
2. Perform a bit-wise AND operation on the IP Address and the Subnet Mask
   Note: 1 AND 1 results in a 1, 0 AND anything results in a 0
3. Express the result in Dotted Decimal Notation
4. The **result** is the **Major Network Address** of this for this host IP Address is **138.101.0.0**

	138.	**101.**	**114.**	**250**
IP Address	10001010	01100101	01110010	11111010
Major Mask	11111111	11111111	00000000	00000000
Network Add.	10001010	01100101	00000000	00000000
	138	**101**	**0**	**0**

Step 3: Broadcast Address for the Major Network Address

Remember that the network mask separates the network portion of the address from the host portion. The network address has all 0's in the host portion of the address while the broadcast address has all 1's in the host portion of the address.

	Network portion		Host portion	
	138	**101**	**0**	**0**
Network Add.	10001010	01100101	00000000	00000000
Major Mask	11111111	11111111	00000000	00000000
Broadcast.	10001010	01100101	11111111	11111111
	138	**101**	**255**	**255**

By counting the number of host bits we can determine the total number of usable hosts for this network (before subnetting).

Host bits: 16

Total number of hosts:

$2^{16} = 65{,}536$

65,536 – 2 = 65,534 (Can't use the all 0's address, network address, or the all 1's address, broadcast address.)

Add this information to our table:

Host IP Address	**138.101.114.250**
Major Network Mask	**255.255.0.0 (/16)**
Major (Base) Network Address	138.101.0.0
Major Network Broadcast Address	138.101.255.255
Total Number of Host Bits Number of Hosts	16 bits or 2^{16} or 65,536 total hosts 65,536 – 2 = 65,534 usable hosts
Subnet Mask	**255.255.255.192 (/26)**
Number of Subnet Bits Number of Usable Subnets (all 0's used, all 1's not used)	
Number of Host Bits per Subnet Number of Usable Hosts per Subnet	
Subnet Address for this IP Address	
IP Address of First Host on this Subnet	
IP Address of Last Host on this Subnet	
Broadcast Address for this Subnet	

Part 2: Determine Subnet Information

Step 1: Translate Host IP Address and Subnet Mask into binary notation

	138.	**101.**	**114.**	**250**
IP Address	10001010	01100101	01110010	11111010
Subnet Mask	11111111	11111111	11111111	11000000
	255.	**255.**	**255.**	**192**

Step 2: Determine the Network (or Subnet) where this Host address lives:

1. Draw a line under the mask
2. Perform a bit-wise AND operation on the IP Address and the Subnet Mask
   Note: 1 AND 1 results in a 1, 0 AND anything results in a 0
3. Express the result in Dotted Decimal Notation
4. The **result** is the **Subnet Address of this Subnet** which is **138.101.114.192**

	138.	**101.**	**114.**	**250**
IP Address	10001010	01100101	01110010	11111010
Subnet Mask	11111111	11111111	11111111	11000000
Subnet Add.	10001010	01100101	01110010	11000000
	138	**101**	**114**	**192**

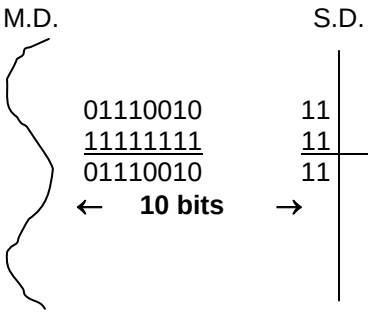
Add this information to our table:

Subnet Address for this IP Address	138.101.114.192

Step 3: Determine which bits in the address contain Network information and which contain Host information:

1. Draw the **"Major Divide" (M.D)** as a wavy line where the 1's in the **Major (Base) Network Mask** ends (also the mask if there was no subnetting). In our example, the Major Network Mask is 255.255.0.0 or the first 16 left-most bits.

2. Draw the **"Subnet Divide" (S.D.)** as a straight line where the 1's in the **given Subnet Mask** ends. *The network information ends where the 1's in the mask end*.

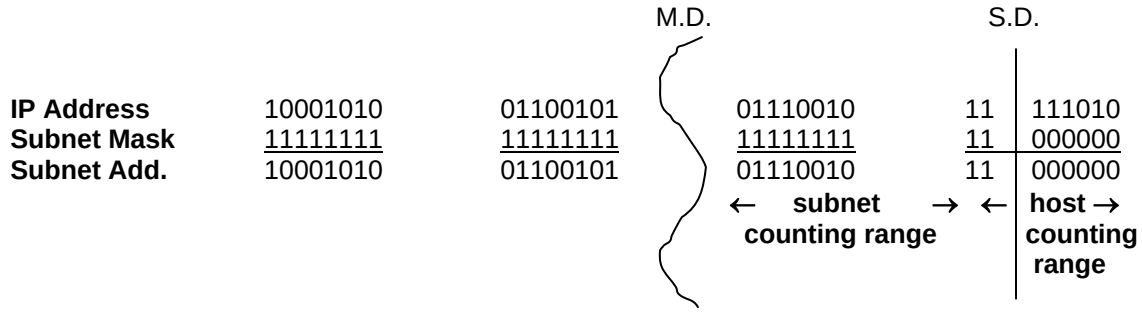


IP Address	10001010	01100101	01110010	11	111010
Subnet Mask	11111111	11111111	11111111	11	000000
Subnet Add.	10001010	01100101	01110010	11	000000

3. The **result** is the **"Number of Subnet Bits"** may be determined by simply counting the number of bits between the M.D. and S.D., which in this case is **10 bits**.

Step 4: Determine bit ranges that are for subnets and for hosts:

1. Label the **"subnet counting range"** between the M.D. and the S.D. (these are the bits that are being incremented to make the subnet numbers or addresses).
2. Label the **"host counting range"** between the S.D. and all of the way to the end on the right (these are the bits that are being incremented to make the host numbers or addresses).



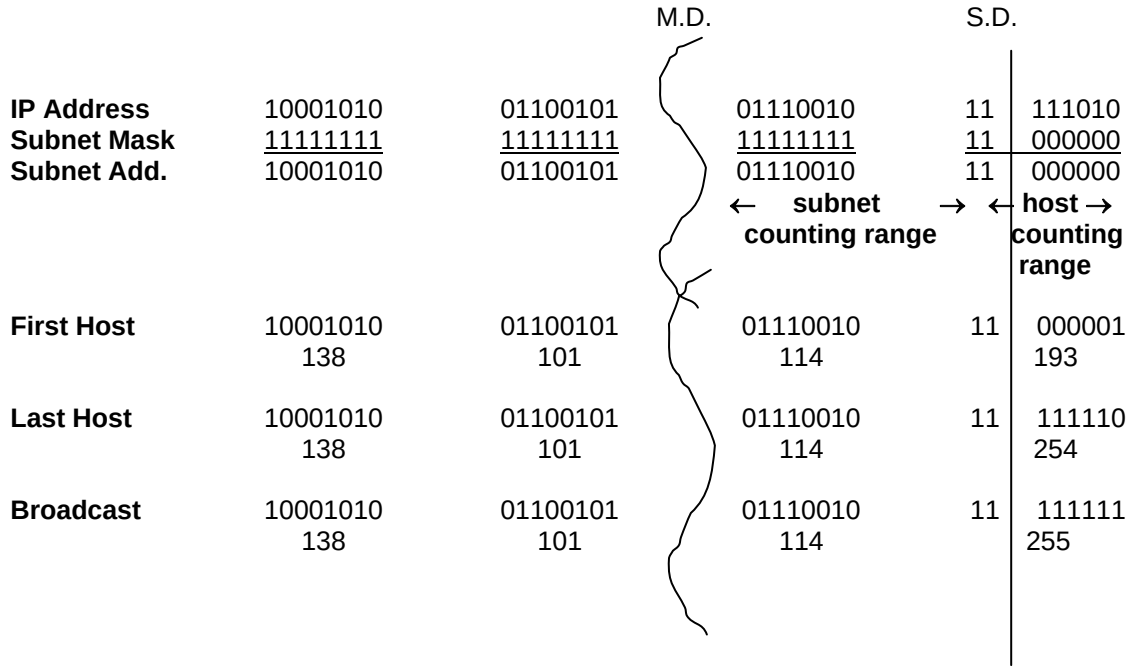
Step 5: Determine the range of host addresses available on this subnet, and the broadcast address on this subnet:

1. Copy down all of the network/subnet bits of the Network Address(i.e. all bits before the S.D.)

2. In the host portion (to the right of the S.D.) make the host bits all 0's except for the right most bit (or least significant bit), which you make a 1. This gives you the *first* Host IP Address on this subnet, which is the *first part* of the **result** for **"Range of Host Addresses for This Subnet,"** or in our example **138.101.114.193.**

3. Now, in the host portion (to the right of the S.D.) make the host bits all 1's except for the right most bit (or least significant bit), which you make a 0. This gives you the *last* Host IP Address on this subnet, which is the **last part** of the **result** for **"Range of Host Addresses for This Subnet,"** or in our example **138.101.114.254.**

4. In the host portion (to the right of the S.D.) make the host bits all 1's. This gives you the *Broadcast* IP Address on this subnet. This is the **result** for **"Broadcast Address of This Subnet,"** or in our example **138.101.114.255.**



Let's add some of this information to our table:

Host IP Address	**138.101.114.250**
Major Network Mask	**255.255.0.0 (/16)**
Major (Base) Network Address	138.101.0.0
Major Network Broadcast Address	138.101.255.255
Total Number of Host Bits Number of Hosts	16 bits or 2^{16} or 65,536 total hosts 65,536 – 2 = 65,534 usable hosts
Subnet Mask	**255.255.255.192 (/26)**
Number of Subnet Bits Number of Usable Subnets (all 0's used, all 1's not used)	
Number of Host Bits per Subnet Number of Usable Hosts per Subnet	
Subnet Address for this IP Address	138.101.114.192
IP Address of First Host on this Subnet	138.101.114.193
IP Address of Last Host on this Subnet	138.101.114.254
Broadcast Address for this Subnet	138.101.114.255

Step 6: Determine the number of usable subnets

The number of usable subnets depends upon the equipment and the network administrator. Subtract 0 to use all subnets, subtract 1 if not using either the all 0's or all 1's subnet, subtract 2 if not using the all 0's and all 1's subnets.

The number of subnets is determined by how many bits are in the *subnet counting range* (in this example, 10 bits) minus 1 for the last subnet, the "all ones subnet" which is sometimes not used. The first subnet, known as the "all zeroes subnet" is a usable subnet in this example.

1. Use the formula $2^n – 1$, where n is the number of bit in the *subnet counting range*.
2. $2^{10} – 1 = 1024 – 1 = 1023$
3. Subtract 1 from the number of usable subnets (the "all zeroes" subnet)

Number of Subnet Bits Number of Usable Subnets (all 0's used, all 1's not used)	10 bits $2^{10} – 1 = 1024 – 1 = 1023$ usable subnets

Step 7: Determine the number usable hosts per subnet

The number of hosts per subnet is determined by the number of host bits (in this example, 6 bits) minus 2 (1 for the subnet address and 1 for the broadcast address of the subnet).

$2^6 – 2 = 64 -2 = 62$ hosts per subnet

Number of Host Bits per Subnet Number of Usable Hosts per Subnet	6 bits $2^6 – 2 = 64 -2 = 62$ hosts per subnet

Final Answers

Host IP Address	**138.101.114.250**
Major Network Mask	**255.255.0.0 (/16)**
Major (Base) Network Address	138.101.0.0
Major Network Broadcast Address	138.101.255.255
Total Number of Host Bits Number of Hosts	16 bits or 2^{16} or 65,536 total hosts 65,536 – 2 = 65,534 usable hosts
Subnet Mask	**255.255.255.192 (/26)**
Number of Subnet Bits Number of Usable Subnets (all 0's used, all 1's not used)	10 bits 2^{10} – 1 = 1024 – 1 = 1023 usable subnets
Number of Host Bits per Subnet Number of Usable Hosts per Subnet	6 bits 2^6 – 2 = 64 -2 = 62 hosts per subnet
Subnet Address for this IP Address	138.101.114.192
IP Address of First Host on this Subnet	138.101.114.193
IP Address of Last Host on this Subnet	138.101.114.254
Broadcast Address for this Subnet	138.101.114.255

Borrowing Bits

How many bits to you need to borrow to create a certain number of subnets or a certain number of hosts per subnet?

Using this chart, you can easily determine the number of bits you need to borrow. Remember to:

- The number of usable subnets depends upon the equipment and the network administrator. Subtract 0 to use all subnets, subtract 1 if not using either the all 0's or all 1's subnet, subtract 2 if not using the all 0's and all 1's subnets.
- Subtract 2 for the usable number of hosts per subnet, one for the subnet address and one for the broadcast address of the subnet.

2^{10}	**2^9**	**2^8**	**2^7**	**2^6**	**2^5**	**2^4**	**2^3**	**2^2**	**2^1**	**2^0**
1,024	**512**	**256**	**128**	**64**	**32**	**16**	**8**	**4**	**2**	**1**
Number of bits borrowed:										
10	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	
1,024	**512**	**256**	**128**	**64**	**32**	**16**	**8**	**4**	**2**	**1**
Hosts or Subnets										

Possible Subnet Mask Values

Because subnet masks must be contiguous 1's followed by contiguous 0's, the converted dotted decimal notation can contain one of a certain number of values:

Dec.	*Binary*
255	11111111
254	11111110
252	11111100
248	11111000
240	11110000
224	11100000
192	11000000
128	10000000
0	00000000