What is an Internet Address?

The internet is composed of a loose collection of computers, cell phones, and other devices that need to communicate with each other. Just like houses on a street, these machines need to be able to find each other in order to communicate. For a house or business, you have an address such as 123 South Broadway, Denver, Colorado.

For the Internet, machines find each other using an "Internet Address". This is normally seen as four numbers separated by periods. For Example, a home computer may have an address such as 192.168.0.2.

Today as I type this, the MSN web site that you can go to using Internet Explorer is at:
207.68.173.76. This is great for computers which really like numbers, but for us mortals, it is much easier to remember www.msn.com .

Luckily, the folks that designed the Internet, recognized this and developed something called DNS which stands for Domain Name System. When you open your browser and type in the name of your favorite web site such as www.google.com, your browser sends out a message to the DNS machines and asks what the address for www.google.com is. The DNS system looks up the current address and sends it back to you. Then your browser goes to the address it just received and opens up the page so you can view it. This is great in case Google moves their computers to a new state. You don't have to keep up with what the current address is!

This is similar to using the phone book to get a phone number.

Techie Alert! What follows is a more advanced discussion of Internet Addresses.
If you ever wanted to understand how the Internet Address really works to locate a specific computer, read on….

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Calculating IPs, Subnet Masks, and Broadcast Masks

Octets: A little background information

Most of the computers that people work with store information 8-bits at a time. Each of these groups of 8-bits is referred to as a byte. A computer may have 512 million bytes of memory or a 20 giga-byte hard drive. These numbers all relate to how many of these 8-bit storage locations are available.

IP addresses consist of a four-octet number commonly displayed in dotted decimal format, eg. 207.68.173.76. Each of the four numbers is the decimal value of the 8-bit binary number that composes the number. Since 8 bits can represent numbers from 0 through 255 (0 through 2^8-1), an IP address can range from 0.0.0.0 through 255.255.255.255 although there are restrictions on the use of certain addresses.

IP addresses fall into one of several classes depending on the value of the first decimal digit.

This is used to logically break up the internet into various logical groups. The purpose of these classes is to create a small number of very large networks which can be used by the military for instance, a much larger number of medium sized networks which can be used by large businesses, and a huge number of very small networks that can be used by everyone else.

When this scheme was first developed, there were just a handful of computers located at the major universities around the country. With a 4-byte address, you could address over 4 billion machines. In the early 1980s when they were starting to build the early version of the Internet, they thought that this was basically an infinite number of addresses. IBM at one time estimated that there was a world-wide need for about 100 super computers. No one considered the possibility of running out of addresses ever! Then the microcomputer went from a toy for Geeks to a serious business machine with Internet connectivity and by the year 2000, we almost ran out of addresses.

Class #	Binary Representation	Decimal Range	Network Number	Host Number
Class A	**0**xxxxxxx	0-127	Bits 1-7	Bits 8-31
Class B	**10**xxxxxx	128-191	Bits 2-15	Bits 16-31
Class C	**110**xxxxx	192-223	Bits 3-23	Bits 24-31
Class D	**1110**xxxx	224-239	Multicast	
Class E	**1111**xxxx	240-255	Reserved	

Class #	Network / Host in Binary
Class A	**0**NNNNNNN.HHHHHHHH.HHHHHHHH.HHHHHHHH
Class B	**10**NNNNNN.NNNNNNNN.HHHHHHHH.HHHHHHHH
Class C	**110**NNNNN.NNNNNNNN.NNNNNNNN.HHHHHHHH
Class D	**1110**NNNN.NNNNNNNN.NNNNNNNN.NNNNNNNN
Class E	**1111**NNNN.NNNNNNNN.NNNNNNNN.NNNNNNNN
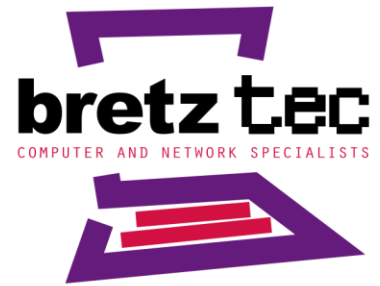
The Class A Network

Class A addresses use 7 bits for the network part of the address and 24 bits for the node part of the address. This creates 128 Class A networks each containing 2^{24} = 16 million hosts. This network range is dedicated to a small number of very large networks such as IBM.

The Class B Network

Class B addresses use 14 bits for the network part of the address and 16 bits for the host part of the address. This results in 16,384 networks each containing 65535 host addresses. This network range is dedicated to large corporations and similar users.

The Class C Network

Class C addresses use 21 bits for the network part of the address and 8 bits for the host part of the address. This results in 2,097,152 networks each containing 256 hosts addresses. This network range is dedicated to small networks.

The Class D Network

Class D addresses are used for multicast. This allows a computer to send a message to everyone on the local network at one time. Sort of like shouting!

The Class E Network

Class E addresses are reserved and commonly used for experimental purposes.

Subnetting

This example uses the public IP address of IBM www.ibm.com which is currently 129.42.xxx.xxx.

One of the networks assigned to IBM is 129.42.xxx.xxx. Since the first dotted decimal digit is 129, this identifies the network as a Class B address. This network allows IBM to have up to almost 65536 addressed devices on the network. As a single flat network, this large number of devices on the same network is not practical. A solution is to allow the owner of a network to break a network into many smaller easily managed networks. This process is called sub-netting.

This is similar to the arrangement of phone numbers (before LNP) such as (303) 757-5626 where the first part (303) indicates the state or geographical locality, the second part 757- indicates the Central Office serving the customer, and the third part indicating the customer number on the switch.

As an example using the 129.42.xxx.xxx network sited above, IBM could create 256 sub-networks each containing 256 devices. Note: This example is for illustration purposes only and does not represent the actual layout of the IBM network. The Omaha office could be assigned 129.42.001.xxx and the Denver office could be assigned 129.42.002.xxx and so on until all 256 subnets are used

up. The Internet authority that controls IP addresses does not care how IBM organizes their network as long as they only use their address range of 129.42.xxx.xxx.

We now have a series of 256 sub-networks within the 129.42.xxx.xxx network. To communicate between these networks a device called a router is used. A router has two basic functions. First, a router isolates traffic to the networks where it is supposed to be. Secondly, a router forwards traffic based on certain parameters to the destination. What this means is that if two devices on a single network are communicating, the traffic never leaves the network they are on. Also, if two devices on two networks are communicating, the traffic never appears on network number three unless network three is on the path between the two devices.

The IBM network is separated from the Internet by use of a router or similar device. This is also the method used to separate the various subnets from one another. The function of a router is to route traffic to the correct network or sub-network. If someone at Microsoft sends e-mail to someone at IBM, the name ibm.com in user@ibm.com is converted to an IP address. That message is routed through the Internet until it reaches the IBM router where the address is compared to a table of addresses stored in the router. Since the address matches a IBM address, it is passed on to the correct IBM sub-network.

Once we decide how we want to divide our network up into sub-networks, we have to tell this information to the various devices so they can communicate correctly. This is where the subnet mask and broadcast mask come in. A subnet mask basically tells the various devices how much of the address is to be regarded as the network address and how much of the address is the address of the device on the local network.

Using the example of 256 networks with 256 hosts per network given above we have:

IP address = 129.42.235.007. In binary this equals
10000001.001010100.11101011.00000111

For the subnet address, a 1 indicates a network component, and a 0 indicates a host address component. To achieve 256 subnets we need 8 bits since $2^8 = 256$. This gives us a subnet address of 255.255.255.0. In Binary this equals
11111111.11111111.11111111.00000000

For the device to determine which part of the address belongs to the network and which part belongs to the hosts we use the logic AND function. Any bit position in the Subnet address that is a "1" represents a bit in the IP address in the same position that belongs to the network. Any "0" bit position indicates a host address on that network. From above we see that the first three dotted decimal digits belong to the network component of the address and the last dotted

decimal digit belongs to the host address component. Therefore, we have network 129.42.235.7 with host number 7 on that network.

If 129.42.235.007 sent a message to 129.42.235.010, host number 7 would use the above procedure to generate the network address of the destination. Then the originator would XOR the Originator's network address to the Destination's network address. Since the XOR function will give a "0" if the bits in the same position match, a value of all zeros means they are both on the same sub-network. Therefore in this case the Originator recognizes the destination as being on the same sub-network and sends the message directly to host 10. The host address is calculated by subtracting the network address from the IP address.

If 129.42.235.007 sent a message to 129.42.119.010, host number 7 would AND the destination address with the subnet address to get the network component of the address. This network address is compared to the originator's network address using the XOR function and it would recognize that the destination is not on the local network and send the message to the appropriate router to be forwarded to the destination. A table of the available routers is maintained on each machine to be used for address resolution.

Originator:
IP = 129.42.235.007
Subnet Mask = 255.255.255.0
Network Address = 129.42.235.0
Host Address on the network = 7

Destination:
IP = 129.42.119.010
Subnet Mask = 255.255.255.0
Network Address = 129.42.119.0
Host Address on the network = 10

Originator ANDs Destination IP address to Subnet mask to calculate the network address.
Originator XORs Destination network to Originator network which do not match.
Originator sends message to the appropriate router to be forwarded to the destination's network.

Broadcast Address:
In each network or sub-network, there is a special address called the broadcast address that allows a host on the network to broadcast information to all other hosts on the network. This address is identified as having all "1s" in the host part of the IP address. For the Originator example above with an IP address of 129.42.235.007, the broadcast address would be 129.42.235.255. (255 is the decimal value for a binary value of 111111)

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Sub-netting (Advanced)

Sub-netting does not have to use a full dotted decimal digit. While a subnet mask of 255.255.255.0 is good for some situations, it is not appropriate for all situations. If a Small Office is connected to the IBM Network and only has four or five IP addresses assigned, an 8-bit subnet address will assign 256 IP addresses to the subnet supporting the Office. This wastes over 240 IP addresses. There are only 254 subnets that can be assigned using 8-bits for the subnet mask. If the subnet address is adjusted to use 10-bits, this now allows our Class B network to support 1022 (1024-2) sub-networks of 62 (64-2) IPs each. We can now support many more subnets and a sparsely populated subnet wastes fewer IP addresses.

For instance, if IBM uses a 10-bit subnet mask for its Class B addresses.

Subnet 1 = IP addresses from 0...63
Subnet 2 = IP addresses from 64...127
Subnet 3 = IP addresses from 128-191
Subnet 4 = IP addresses from 192-255

ie., IP address 129.42.235.200 would be in the 4th subnet supported by the 129.42.235.xxx subnetworks.

Originator:
IP = 10000001.00100010.11101011.11**001000** = 129.42.235.200 (host in bold)
Subnet Mask = 11111111.11111111.**11111111.11**000000 = 255.255.255.192
Network Address = 10000001.00100010.11101011.11000000 = 129.42.235.192
Host Address on the network = 8
Broadcast Address = 10000001.00100010.11101011.11**111111** = 129.42.235.255

The Broadcast address is calculated by taking the Network address:
10000001.00100010.11101011.11000000
Adding the value of the host address of all 1s (only 6 bits for the host address)
111111 = 63

```
 10000001.00100010.11101011.11000000        Network Address
+00000000.00000000.00000000.00111111        Broadcast Address  (all 1s)
= 10000001.00100010.11101011.11111111        Full Broadcast address
= 129.42.235.255                             Dotted decimal
```

Subnet Usage Table for IBM - (AAA.BBB.CCC.Subnet)

Subnet 1 = IP addresses from 0...63
Subnet 2 = IP addresses from 64...127
Subnet 3 = IP addresses from 128-191
Subnet 4 = IP addresses from 192-255
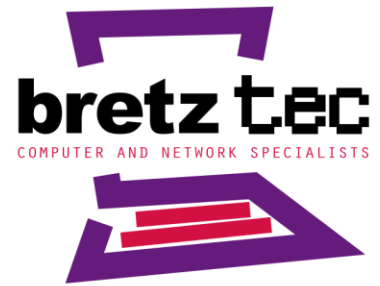
Generic Subnet Usage Table (10 Bit Subnet Mask)
Subnet Mask = 11111111.11111111.**11111111.11**000000 = 255.255.255.192

Use	Subnet 1	Subnet 2	Subnet 3	Subnet 4
All 0's	0	64	128	192
Default Router	1	65	129	193
Reserved	2	66	130	194
Reserved	3	67	131	195
Reserved	4	68	132	196
Reserved	5	69	133	197
User IPs	6	70	134	198
User IPs	…	…	…	…
User IPs	62	126	190	254
All 1's	63	127	191	255

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