12.1.4 Subnet Masks

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Subnet Masks 0:00-0:27

When managing IP addresses on Linux systems, you not only need to understand how IP addresses work, but you also need to understand the role of the subnet mask. If you've ever configured a system with an IP address, you probably noticed that, in addition to an IP address, you also had to assign a subnet mask. Have you ever wondered what this thing is? In this lesson, we're going to talk about it. We're going to learn about what subnet masks are, in this lesson, and how they work.

Net Addressing 0:28-5:03

In order to understand how a subnet mask works, you first need to understand that any IP address that is assigned to a host is actually divided into two parts. We have the network portion of the address, and we have the node portion of the address.

The network portion of the address, of an IPv4 address, is used to identify which network the host resides on. In this example, a host that is assigned an IP address of 192.168.1.1 resides on a network with an address of 192.168.1.0.

The rest of the address uniquely identifies a particular host on the network. In this case, it's node number 1 on that network. The important thing to remember is that every computer, every host, on the same network must have exactly the same numbers in the network portion of their IP address. Conversely, they must have unique numbers in the node portion.

Really, you can think of it as like street house and street numbers. Say we have a couple of streets like this, and we have a house here and a house here and a house here, and we're delivering mail to all of these houses. Well, all of these houses are built on the same street. If you look at the address of the house, the street name is going to be exactly the same for each house. However, each house is going to have a unique house number assigned to it. This might be 1, this is 2, and this is 3.

It works exactly the same way on an IP network. The network is kind of like the street address. You know that all three of these houses are on the same street because they have exactly the same street address.

Likewise, if you have IP hosts on a network, if they have the same network address you know that they're on the same network segment. And just as with houses, you want to have a unique number assigned to each computer on that network, even though the network address is the same-- the equivalent of living on the same street, each computer has to have a unique number assigned to it.

Imagine the problems that would occur if you had several houses on the same street that had exactly the same address! Let's say each one of these had a house number of 1. Well, if you have someone who is delivering a package to these houses and it says, "Go to this street and deliver it to house number 1," you're like, "Well, wait a minute! I've got three number 1 houses. Which one does it go to?"

It works exactly the same way with computers on an IP network. If you had multiple computers with the same address, how would we know which one a particular piece of data was addressed to if they all had the same address?

So far so good, right? Here's the thing that usually trips folks up when they're first learning about IPv4 addresses. And that is the fact that the amount of the address that is used for the network and the amount that is used for the node address can change, depending upon what the address is. For some addresses, only the first octet is used for the network address and the rest is used for the node address.

In this example, we've used the first three octets for the network address and only the last octet for the node address. To help clear things up, understand that three default subnet masks have been assigned: 255.0.0.0, 255.255.0.0, and 255.255.255.0. The important thing to remember here is that any octet with a 255 in it for a default subnet mask indicates that that is the network portion of the address. Any octet with 0 indicates that is the host or node portion of the address.

In this example, the first three octets are used for the network address, and only the last octet is used for the node. The subnet mask would be this one right here. We have 255, that maps to that octet; then we have another 255, that maps to that octet; and then we have to have a third 255 for this octet; then we would have a 0, which maps to the node portion of the address. Just remember, any time you see a 255, that means that octet is used for the network. Any time you see a 0, you know that octet is used for node addresses.

How Subnet Masks Work 5:04-6:38

To understand how this works, you need to remember that IP protocol, along with the operating system running on the computer, will see these IP addresses not as decimal numbers, but as binary numbers. In this example, here is the binary version of our IP address: 192.168.1.1.

In addition to seeing the IP address in binary notation, your system also sees the subnet mask in binary notation, too.

In this example, our subnet mask--as we looked at before--is 255.255.255.0. The binary equivalent of 255 is eight ones. We have eight ones, eight ones, eight ones, and the binary equivalent of 0 is just all zeros.

Here's the key thing to remember. Remember, we said earlier that any time you see a 255 in an octet, it indicates that that octet is used for the network address. And any time you see a 0, it is used for the node address. This is why: any time you see a one in any bit of the subnet mask, it indicates that that corresponding bit in the IP address is for the network address. In this case we have 24 ones--hope I drew enough of them there--24 ones in the subnet mask. That means the first 24 bits of the binary IP address are used for the network address. And we have all zeros over here, which means all of these bits are used for the node address.

Default IP Address Classes 6:39-10:57

IP addresses are divided into five different default classes, and each address class has its own default subnet mask. For our purposes here, we're not concerned with the last two. We're only concerned with the first three address classes-- first of all, class A. Class A IP addresses use the default subnet mask shown here.

The important thing to remember about a class A IP address is that the decimal value of the first octet of that IP address has to be within the range of 1 to 126. Using the default subnet mask of 255.0.0.0., that means that only the first octet of the IP address is used for the network address and the last three octets are the node address.

For example, let's suppose we have an IP address of 10.0.0.2. We automatically know that it's a class A address because it falls within this range. It's because the 10 in the first octet falls within this range; it's between 1 and 126. We know that the default subnet mask is 255.0.0.0.

Remember, we said any time you see an octet with 255 in it, it means it's the network portion of the address, and the octet with a zero is the network portion of the address. Therefore, we know that this much of the address is used for the network address, and this much of the address is for the host portion of the address.

Because we just used the first octet with a class A address for the network portion of the address, we can't have very many networks. We can only have a maximum of 126 total networks with a class A address, and that's not very many. The nice thing about a class A address is, because we're using three octets on the other side for hosts, we can have like 16.7 million host addresses on each network. That is a lot.

In addition to class A addresses, you can also have a class B address. In a class B address, the decimal value of the first octet must be between 128 and 191. An example is shown here: 172.17.0.1. How do we know that's a class B address? Because 172 falls between 128 and 191. Notice that a class B address has a subnet mask of 255.255.0.0.

We know, using the rule that we talked about, that because the first two octets of the subnet mask have a 255 in it, that the first two octets of this class B address are used for the network and the last two octets are used for the host portion of the address. With a class B address, you can have 16,384 possible networks, and on each network you can have 65,534 hosts.

Last, we need to look at the class C address. In a class C address, the decimal value of the first octet of the IP address must be between 192 and 223. For example, the IP address that we've been working with so far in this lesson, 192.168.1.1, is a class C address. How do we know that? Because the first octet of that address is 192, which falls in this range 192 to 223.

As you can see, for a class C address the default subnet mask is 255.255.255.0. Therefore, using our subnet mask rule, we know that the first three octets of the address are used for the network portion of the address and the last octet is used for the host portion.

Because we're using so many octets for the network portion of the address, we can have a lot of them--2,097,152 possible class C networks! But because we're using just the last octet for the host address, and because we can't use 0 and we can't use 255, that means we can only have a maximum of 254 hosts on any one of these given networks.

CIDR Notation 10:58-12:11

Subnet masks are sometimes noted using a type of shorthand called CIDR notation. And this is done by simply adding a forward slash (/) at the end of the IP address, followed by the number of bits in the subnet mask.

In this example, we have an IP address of 192.168.1.1/24. This means that we're using a 24-bit subnet mask. And if we were to convert that 24 bits into decimal notation, what would it look like?

Well, we know that 24 divided by eight is three, so that means that we have three octets with ones in them. 11111111, which would equate to a subnet mask of 255, that's the first 8-bit octet; 255, that's the second 8-bit octet; 255, third octet; and then a 0. There are our eight bits, eight bits, eight bits.

If you sum them up, you get 24. And by the way, when we use CIDR notation, the subnet mask is frequently referred to as the prefix. If you hear the word prefix, we're talking about the subnet mask.

Summary 12:12-12:18

That's it for this lesson. In this lesson, we discussed the role and function of a subnet mask and then we ended this lesson by talking about what subnet masks are and how they work.
