12.3.1 IPv6 Addressing

Click one of the buttons to take you to that part of the video.

IPv6 Addresses 0:00-0:57

In this lesson, we're going to look at the IPv6 network protocol. Currently, the world's supply of registered IPv4 addresses is exhausted. There are a few, but not very many, IPv4 addresses currently available for assignment by IANA (Internet Assigned Numbers Authority).

To address this issue, most organizations reduce the number of registered IP addresses that they actually need by implementing some type of NAT router. However, really, using a NAT router is more of a short-term solution.

To fully correct this address shortage issue, what we really need is a new version of the IP protocol that can handle the number of IP addresses that the modern computing world needs. In order to accomplish this, the IP version 6 protocol, or IPv6, is being rolled out throughout the world. IPv6 is expected to completely replace IPv4 over the next decade or so.

IPv6 0:58-4:47

Nearly all Linux distributions support both IPv4 and IPv6. Instead of using 32 bits to define an IP address, like IPv4 does, IPv6 uses 128 bits to define an IPv6 address. This allows for a lot of available IP addresses. Using a 128-bit address provides 3.4 times 10 to the 38th power total unique IPv6 addresses, and hopefully this will be enough. You never know.

IPv6 addresses are composed of eight, four-character, hexadecimal numbers. Each one of these four-character hexadecimal numbers is called a quartet. You'll notice down here that these quartets are separated by a full colon now, instead of a period as we saw with an IPv4 address.

Because these are hexadecimal numbers, you'll notice that we have letters within the IPv6 address in addition to just numbers. That is not what we saw with IPv4. Remember, a hexadecimal number is a base 16 number instead of a base 10 number that we're used to with decimal notation.

Because we're dealing with 16 numbers, we start with zero and then we go one, two, three, four, five, six, seven, eight, nine. That's normal. In decimal notation, we would then start over and go to 10, right? Well, because we're dealing with base 16 numbers with hexadecimal, we still have five more numbers to go.

We actually go 0 through 9, and then we go A, B, C, D, E, and F. And then we start over. That's why there are letters down in this IPv6 address.

An IPv6 address is divided into two parts in much the same way that a traditional IPv4 address is divided. With an IPv4 address, we have the network portion of the address, and we have the host portion of the address. The same principle applies with an IPv6 address. We just use slightly different terminology. The concept is still the same, however.

The first 64 bits of an IPv6 address is the prefix. The prefix is composed of the network address, as well as the subnet address for the IP network. Basically, it's equivalent to the old IPv4 network portion of the IP address. In fact, we've referenced the prefix in IPv6 using the same CIDR notation that we did for IPv4 addresses.

One of the neat things about IPv6, however, is that because of the huge address space available with IPv6 addresses, we don't need to create all the custom subnet masks that we did with IPv4. Instead, pretty much everybody just uses a 64-bit prefix. There are exceptions, but they are kind of rare. Pretty much everybody just uses a 64-bit prefix.

Therefore, at the end of the address, we can just put /64 to indicate that our prefix is 64 bits long. And just as with IPv4, the last part of the address is the interface ID, which is basically the same thing as the IPv4 host portion of the address. This is the unique portion that is assigned to an individual host.

Just as with IPv4, if we have two hosts on the same network segment, and we want them to be able to communicate with each other with IPv6, then the prefix has to be the same on both systems. And just as with IPv4, the interface ID has to be unique.

You can't have two hosts with the same IPv6 address. Because these IPv6 addresses are so incredibly long, you will frequently see them abbreviated.

IPv6 Addresses Abbreviation 4:42-7:06

This can be done by eliminating all the long strings of multiple zeros that frequently occur in an IPv6 address. For example, consider this address. We have these first two quartets that are populated with numbers greater than zero. This quartet, this quartet, this quartet, and this quartet just have zeros in them.

Well, we don't necessarily need to see all those zeros. What we can do is omit them by putting a double colon between where the zeros start and where the zeros end. That allows us to use a much shorter IPv6 address, but we still know that it's a full IPv6 address because we know that everything between these two colons right here is a zero.

There are a couple of things that you have to remember about in-line zero suppression, as we call it with IPv6. First, you can suppress a quartet only if it contains nothing but zeros.

Notice here that we have a zero in the first quartet, we have two zeros right here in the second quartet, so you might be inclined to start your suppression right here and go all the way over to here. Well, you can't do that, because you have to look at the entire number in the quartet, not just the zeros within it.

Because we have a number of CD00, we actually have a number in that quartet which is greater than zero; therefore, we cannot start the zero suppression right there. The other thing you have to be aware of is the fact that you can use suppression only once within an IPv6 address.

If we had, say, a number right here, instead of being 0000, let's say this is 0BAD, "oh bad." In this situation, you might be tempted to use a double suppression, where you would suppress the zeros here and here. Put the 0BAD, and then do another suppression right here to get rid of those zeros. Can't do that.

You can do one or the other, but not both. The general rule is suppress the longest string of zeros. In this situation, you would suppress these zeros with a double colon, and then you would leave these zeros intact. Because remember, you can suppress only one set of zeros. As you can see, IPv6 is quite a bit more complex than IPv4.

Global Unicast IPv6 Addresses 7:02-9:39

In fact, there are three different major types of IPv6 addresses that you have to be familiar with. Global unicast, unique local, and link-local. We're going to talk about global unicast addresses first.

Global unicast IPv6 addresses function in a similar manner to public registered IPv4 addresses. Basically, these are globally unique, registered, assigned IPv6 addresses.

Typically, an organization that wants to deploy IPv6 will be assigned by IANA, a registered unique global routing prefix, which is basically the equivalent to an IPv4 network address. This global routing prefix is 48 bits long.

Here's the key point. Every global routing prefix that is used on a public network, such as the internet, has to be globally unique. This means that nobody in the world should be using the same global routing prefix. This ensures that every single IPv6 address assigned to individual network hosts is globally unique as well.

Notice here that the global routing prefix that gets assigned to you is usually 48 bits long. Remember, we said earlier that by default, just about everybody uses a 64-bit prefix with IPv6 addresses. What do you do with the remaining 16 bits?

Well, you use those to create your own subnets. Because of the amount of space we're dealing with here--16 bits-- you can define a whole bunch of subnets within your organization. You can define 2 to the 16th power subnets in your organization, and I can guarantee you will probably not need that many.

Because we have a global routing prefix assigned to our organization, however, every single subnet within your organization will use the same global routing prefix assigned by IANA and your ISP. But they could have a different value over here in the subnet portion of the prefix, depending upon which subnet in your organization they currently reside upon.

The focus with global unicast IPv6 addresses is that global routing prefix we've been talking about right here. The actual interface IDs, we can assign whatever we want to whoever we want within the organization, because this part of the address over here, the global routing prefix, ensures the global uniqueness that we need.

When you're implementing IPv6, you don't actually have to use a global unicast address if you don't want to.

Unique Local IPv6 Addresses 9:33-11:45

If appropriate, you could implement unique local addressing instead. Unique local IPv6 addresses are similar to private IPv4 addresses that are normally used for networks that are not connected directly to the public network.

Remember, with IPv4, we can use private IPv4 addresses inside our organization and then translate them to registered public IPv4 addresses by a NAT router. The same concept kind of holds true with IPv6 using unique local addressing.

Unique local addresses are not registered, so they can't be used on a public network just like with IPv4. Unless, of course, you implement some type of network address translation to take the unique local address and translate it into a global unique address.

You can always recognize a unique local IPv6 address by the first two characters in the first quartet. The first eight bits of unique local addresses always use a prefix that begins with FC or FD. Then the next 40 bits within the prefix are used for the global ID, which is just a randomly generated number.

The goal here, because it's randomly generated, is to create a high probability of global uniqueness. We're not guaranteeing global uniqueness, but because the number is so big, there's a pretty high probability that it's going to be globally unique.

In essence, unique local addresses are actually designed to be globally unique, even though they can't be used on the internet; that is not the case with private IPv4 addresses. Then the remaining 16 bits within the prefix is used for creating your subnets, just like we did with global unique IPv6 addresses. And then the rest of the address is used for assigning to individual hosts.

The key thing to remember about unique local addresses is that they're not registered, so you don't actually have to go apply for one and have it assigned to you. You can use whatever unique local IPv6 address you want, as long as it begins with FD or FC. Before we end, we need to look at one more type of IPv6 address.

Link Local IPv6 Addresses 11:42-13:39

This is one you're actually probably going to work with a lot. It's the link-local address. IPv6 uses a special unicast address called the link-local address just for communications within the local network segment-- on the local network only.

Most network routers are configured to automatically not forward packets addressed to link-local addresses on other subnets. That means that it can't be routed, and as such, link-local addresses cannot be used for communications between hosts that reside on different network segments, because the router isn't going to let that traffic through.

What do you use link-local IPv6 addresses for, then? Well, they're used for automatic address configuration, discovering neighboring devices, and they can be reused really well within the network segment for routerless subnets.

A link-local address will always begin with FE8, FE9, FEA, or FEB. These are the first 10 bits of the address. The entire link-local prefix is 16 bits long. That's the first quartet. And then the next 48 bits comprise the local link ID.

Together, what you basically get is the local network address. Then we assign individual hosts the interface ID, just like we did with the other two types of IPv6 addresses. Earlier, I said that you will work a lot with link-local IPv6 addresses.

Why? Because you'll notice that when you're working with IPv6, every time an IPv6 host turns on, it will have at least one link-local address automatically defined and assigned to that interface when the system comes up. Essentially, that allows a basic level of communication between all IPv6 hosts on the same network segment.

Summary 13:40-13:51

That's it for this lesson. In this lesson, we reviewed the IPv6 protocol. We first discussed the need for IPv6. We talked about the structure of an IPv6 address. And then we talked about the three different types of IPv6 addresses.

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