Video - Network, Host, and Broadcast Addresses (11 min)

This video will cover the process of ANDing as it relates to discovering the network address, the host addresses, and the broadcast address in an IPv4 network. In this example, we'll assume that our IP address is 192.168.1.100/24. Our goal is to answer these questions: What is the Subnet Mask? We can see that the subnet mask is /24 in slash notation, but what is it in dotted decimal notation. 2. The Network Address. The network address is the first address in the network. It's a reserved address that cannot be assigned to any host on the network. What is the Broadcast Address? The broadcast address is the last address in the network, and is also a special reserved address that cannot be assigned to a host on the network. And then, since we can't use the network address and the broadcast address, what is the first Usable Host address on the network, and what is the last usable host address on the network that we can use to assign to hosts, whether they're PCs, or printers, or servers, or access points, whatever? We'll start with question one, what is the subnet mask? If our IP address is 192.168.1.100/24 this is our subnet mask in slash notation. The first thing we'll need to do is convert this to binary. So, I've converted /24 into binary. Notice that /24 denotes that there are 24 ones in the subnet mask counting from left to right. If we count them up here we can see that we have eight ones here in the first octet, another eight here makes 16, and then another eight makes 24. Now, I'll need to convert this to decimal. Converted to decimal the subnet mask is 255.255.255.0. Now, how did I do that? Recall that we can take an octet of eight bits and look at it according to the binary place values. The place values start from 2 to the 0 in the one's place, all the way up to 2 to the 7th power, which is the 128's place. If I have all ones in this 8 bit grouping then to convert it to decimal is as simple as adding 128+64+32+16 +8+4+2+1 =255. So, each octet with ones in it equals 255. So, 255.255.255.0 is our answer.

Now, let's go to the second question, what is the network address? First off, the network address, to put a simple answer on it, is the first address in the network. So, in this case, that would be the address 192.168.1.0. Now, you might have assumed correctly that this is the network address. Given a classful class C IP address like 192.168.1.100 and a classful subnet mask of 255.255.255.0 and you would be correct. The network address is 192.168.1.0. But, let's look at it from the perspective of the computer, or for that matter, in the perspective of the router. How does the router know that 192.168.1.100 with this subnet mask has a network address of 1.0? To do this we take the IP address and the subnet mask and we convert them first to binary. So, you can see in this table I have the IP address 192.168.1.100 here on the upper row converted to binary. The subnet mask, 255.255.255.0 is converted to binary on the lower row. The router and your computer can calculate the network address by combining the IP address and the subnet mask. This process is called ANDing. ANDing or Logical ANDing is a logical conjunction where we need to figure out whether the statement A and B is true or false, given a value for A and a value for B. So, logical ANDing really involves a truth table. If A is true and B is true then the truth of A and B with the necessary condition being the conjunction AND is also true. Since A is true and B is true, then A AND B, the requirement AND meaning both of them is also true. But, if A is true and B is false then the conjunction of A and B is false. And if A is false and B is true, then the requirement of AND for both of them is false. And if A is false and B is false then the requirement that they both be true is not met and A AND B is false. We then convert the true and false to the boolean values for true and false, 1 and 0 and we have a boolean truth table. The router and the computer use this logical ANDing with ones standing for true and zeros standing for false to do a logical ANDing operation between the IP address and the subnet mask. So, you can see here in the example the IP address has a one bit, the subnet mask has a one bit, and the conjunction, or the ANDing operation between them results in a one, or a true and a true makes a true. And, so then, a one and a one makes a one and a false and true, or a zero and a one results in a zero. And so now, you have all zeros here. And then, in the next octet you have a one and one equals a one and zero and a one, or false and a true results in false, and a true and a true makes a true, and false and true makes a false and so on and so forth. Notice, in the final octet the subnet mask is all zeros and the result is all zeros, and the resulting network address is 192.168.1.0. This process of ANDing is crucial for how the routers and computers are able to determine the network based upon the IP address and subnet mask.

So, now we know that the network address is the first address in the network, we also know a little bit more about how the network address is actually determined by the computer or the router. And, we can go to question number 3, what is the broadcast address? If the network address is the first address in the network the broadcast address is the last address in the network. In this case, the broadcast address would be 192.168.1.255. Let's plug the 192.168.1.255 broadcast address into our table and do the ANDing operation

just to prove that it's still within the one network. If we go up here to our table I can replace this 100 right here in this fourth octet with 255. So, now you can see that the ip address is 192.168.1.255. If we do an ANDing operation between the broadcast address here and the subnet mask you'll see that it generates the same result. Notice, a true and a true makes a true, a true and a true makes a true, a false and a true makes a false, all the way over. And, when we get to the last octet a true and a false is a false, a true and a false is a false, and you can see that the ending result of network address is still 192.168.1.0. Now, if we go to the next higher address and jump up from 1.255 to 2.0, let's say. We'll change it here, put a one here, and a zero here so now that's a two. And, we change this to all zeros. You can see that we're going to get a different result. Notice the ANDing operation, a false and true is a false, false, false, false, but when we get here a true and true, is a true and a false and a true is a false and now the network address is the two network, 2.0. So, you can see how important ANDing is to defining just where the networks lie. This brings us to the last question. What are the first usable and last usable host addresses in the network? The first usable host address in the network is the first address after the network address. So, in this case, the network address is 0, so the first usable host address would be 1. The last usable host address is the address prior to the broadcast address. So, in this case, the broadcast address is 255, so the last useable host address would be 254. So now, we've answered all five questions, the subnet mask, the network address, the broadcast address, and the first and last usable host addresses, given an IP address of 192.168.1.100/24 with a 24 bit subnet mask.