Video - Converting between Binary and Decimal Numbering Systems (9 min)

In this video, I'm going to discuss binary to decimal conversion, but before I do this, I want to take a look at positional notation, or place values. I have the number 2,168 here. If we look at the place values of the number 2,168, we can see that the place values have the 1's place, the 10's place, the 100's place, the 1,000's place, 10,000, 100,000, and 1,000,000. These are the place values of the base 10 decimal number system. You can see that we have the number 2 in the 1,000's place, so we have 2 1,000s. We have a 1 in 100's place for 100. We have 6 in the 10's place for 60. And we have 8 in the 1's place for 8. So effectively, we have 2 1,000s, 1 100, 6 10s for 60, and 8 1s for 8.

Now, when we're talking about the place values in the decimal number system, we're talking about the powers of 10. You can see that the 1's place is the 10 to the 0. The 10's place, 10 to the 1. The 100's place, 10 to the 2, or 10x10, which is 100. The 1,000's place is the 10 to the 3, or 10x10x10 and so on and so forth. So you can see that the place values are based on powers of 10. If we look at the number 2,168, then, in long form, we can see that, effectively, we have 2 1,000s, 1 100, 6 10s, and 8 1s. And 2,000+100+60+8 totals 2,168. This is the type of counting and addition that we learn as children. The decimal system is base 10. It's based on the fact that you have one: powers of ten, but more importantly, you have 10 characters or 10 numerals in this counting system from 0 all the way up to 9. So that means that in each place value, you can have anywhere from the number 0 up to the number 9. In other words, if I had the number 9,168, I'd simply replace the 2 here with a 9, and now I have 9 1,000s, totaling 9,000 in the 1,000's place. So in any one of these place values, you can have the number 0 all the way up to 9. This is the base 10 decimal number system. If we consider binary and look at it in the same light as decimal, binary is a base 2 number system. There's only two characters, or two numbers: 0 and 1. So under the place values, we can only have 0s or 1s. The place values go from 1, which is 2 to the 0, to 2, 2 to the 1, 4, 2 to the 2, 8, 2 to the 3, or 2x2x2 is 8. 2x2x2x2 is 16-- that's 2 to the 4th power, place value of 16. The 32's place, the 64's place, and the 128's place. Notice that I extended the table to 8 place values. That's because 8 bits is an important grouping of numbers. 8 bits makes a byte in computer processing.

So now I have the place values for essentially 8 bits. If I want to write the number 168 in binary, I just have to find the corresponding place values and plug in either a 1 or a 0. So I'll go to the 128's place and ask myself, "Do I need 128 to reach 168?" Yes, I do. So I'll put a 1 there. Now, do I need a 64? I already have 128. If I add 64, I would get 192, because 128+64 is 192. So the answer's no, so I put a 0. I still have 128 now. Now, do I need a 32? 128+32 is 160, so, yes. I could use a 1 here. Now I have 160. Do I need a 16? No, that would make 176, which would go over my target number of 168. I'll put a 0 here. What about an 8? If I add an 8, I'll hit the number perfectly. 128+32+8 is 168. I'll follow this up with 0s in the 4's place, the 2's place, and the 1's place. And 168 in binary equals 10101000. I now have 1 128. I have 1 32. And I have 1 8. And 128+32+8 equals 168. If we go to the next slide, you can see now that I'm now charged with converting the number to decimal. If I want to go the opposite way and convert this binary number to decimal, all I need to do is plug it into the place values. I'll put it in here as 0. 1... 1, 0... 1, 1... 0, 1. And then add it up. I have a 64, and I have a 32. 64+32 is 96. Plus, I have an 8. That makes 104, plus 4 makes 108, plus 1 makes 109. This number converted to decimal is the number 109.

Now let's look at a full IP address in binary. I'll go to my next slide. And you can see in this next slide I now have a 32-bit IP address, four octets, or 32 bits total. If I want to convert this binary IP address to decimal, all I need to do is count up each individual octet. Let's start with the first one right here. We can see that 1, 1, 0, 0, 0, 0, 0, 0. 128+64 is... 192. Now, the next octet has 10101. Let's do that one. 0, 1... 0, 1... And then all 0s. If we count up the numbers, 128+32 is 160, plus 8 is 168. The next octet is all 0s with a 1 in the last place in the 1's place. This is easy. This is the number 1. All 0s and a 1 in the 1's place makes the number 1. And then, finally, we have a number here. I'll plug it in here into my table. And I have the number 01100101. We can see that 64+32, we've already said is 96, plus 4 is 100, plus 1 is 101. So the conversion of this binary IP address to decimal is 192.168.1.101.