

ment interpretation provides two values for zero: all zero bits and the complement, all one bits. Finally, the two's complement interpretation includes one more negative value than positive values (to accommodate zero).

Which interpretation is best? Programmers can debate the issue because each interpretation works well in some cases. However, computer architects make the decision, and many choose the two's complement scheme because two's complement makes it possible to build low-cost, high-speed hardware to perform arithmetic operations.

3.13 An Example Of Two's Complement Numbers

We said that k bits can represent 2^k possible combinations. Unlike the unsigned representation in which the combinations correspond to a continuous set of integers starting at zero, two's complement divides the combinations in half. Each combination in the first half (zero through $2^{k-1}-1$) is assigned the same value as in the unsigned representation. Combinations in the second half, each of which has the high-order bit equal to one, correspond to negative integers. Thus, at exactly one-half of the way through the possible combinations, the value changes from the largest possible positive integer to the negative integer with largest absolute value.

An example will clarify the two's complement assignment. To keep the example small, we will consider a four-bit integer. Figure 3.8 lists the sixteen possible bit combinations, the decimal equivalent when using the two's complement representation, and the decimal equivalent when using the unsigned representation.

The assignment of values in the figure provides an interesting advantage: except for overflow, the same hardware operations work for either representation. For example, adding one to the binary value 1001 produces 1010. In the unsigned interpretation, adding one to nine produces ten; in the two's complement interpretation, adding one to negative seven produces negative six. The important point is:

A computer can use a single piece of hardware to provide unsigned or two's complement integer arithmetic; software running on the computer can choose an interpretation for each integer.