

APPENDIX

Number Systems

I Introduction

Computers use binary numbers internally, because computers are made naturally to store and process 0s and 1s. The binary number system has two digits, 0 and 1. A number or character is stored as a sequence of 0s and 1s. Each 0 or 1 is called a *bit* (binary digit).

binary numbers

In our daily life we use decimal numbers. When we write a number such as 20 in a program, it is assumed to be a decimal number. Internally, computer software is used to convert decimal numbers into binary numbers, and vice versa.

decimal numbers

We write computer programs using decimal numbers. However, to deal with an operating system, we need to reach down to the “machine level” by using binary numbers. Binary numbers tend to be very long and cumbersome. Often hexadecimal numbers are used to abbreviate them, with each hexadecimal digit representing four binary digits. The hexadecimal number system has 16 digits: 0–9 and A–F. The letters A, B, C, D, E, and F correspond to the decimal numbers 10, 11, 12, 13, 14, and 15.

hexadecimal number

The digits in the decimal number system are 0, 1, 2, 3, 4, 5, 6, 7, 8, and 9. A decimal number is represented by a sequence of one or more of these digits. The value that each digit represents depends on its position, which denotes an integral power of 10. For example, the digits 7, 4, 2, and 3 in decimal number 7423 represent 7000, 400, 20, and 3, respectively, as shown below:

$$\begin{array}{|c|c|c|c|} \hline 7 & 4 & 2 & 3 \\ \hline \end{array} = 7 \times 10^3 + 4 \times 10^2 + 2 \times 10^1 + 3 \times 10^0$$
$$10^3 \ 10^2 \ 10^1 \ 10^0 = 7000 + 400 + 20 + 3 = 7423$$

The decimal number system has ten digits, and the position values are integral powers of 10. We say that 10 is the *base* or *radix* of the decimal number system. Similarly, since the binary number system has two digits, its base is 2, and since the hex number system has 16 digits, its base is 16.

base
radix

If 1101 is a binary number, the digits 1, 1, 0, and 1 represent 1×2^3 , 1×2^2 , 0×2^1 , and 1×2^0 , respectively:

$$\begin{array}{|c|c|c|c|} \hline 1 & 1 & 0 & 1 \\ \hline \end{array} = 1 \times 2^3 + 1 \times 2^2 + 0 \times 2^1 + 1 \times 2^0$$
$$2^3 \ 2^2 \ 2^1 \ 2^0 = 8 + 4 + 0 + 1 = 13$$

If 7423 is a hex number, the digits 7, 4, 2, and 3 represent 7×16^3 , 4×16^2 , 2×16^1 , and 3×16^0 , respectively:

$$\begin{array}{|c|c|c|c|} \hline 7 & 4 & 2 & 3 \\ \hline \end{array} = 7 \times 16^3 + 4 \times 16^2 + 2 \times 16^1 + 3 \times 16^0$$
$$16^3 \ 16^2 \ 16^1 \ 16^0 = 28672 + 1024 + 32 + 3 = 29731$$

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