Ternary Computers

Modern computers use the binary system, i.e., all arithmetical operations are performed internally using 2 as numerical base. An alternative are ternary computers, which compute using base 3. An example of such a machine is the SETUN computer built by Nikolay Brusentsov in 1958 at Moscow University in the USSR.

In base 3, each digit in a number is multiplied by a power of 3 (1, 3, 9, 27, and so on). The three digits $\bar{1}$, 0 and 1 can be used at each position, where $\bar{1}$ means -1. For example, the ternary number 101 is equal to the decimal number 10, since $1\times9 + 0\times3 + 1\times1 = 10$. The ternary number $1\bar{1}0$ is equal to the decimal number 6, since $1\times9 + (-1)\times3 + 0\times1 = 6$. This was the kind of coding used in the SETUN computer. Positive and negative numbers can be represented in this way without having to write a sign in front of the number.

It is not difficult to prove that the ternary system is more compact than the decimal or binary system. Assume, for example, that we are given 30 cardboards on which we can write decimal, binary or ternary digits. Using the decimal system we can only represent numbers with up to 3 decimal places (since we need ten cardboards, numbered 0 to 9 for each decimal position). Using the binary system, we could write numbers with up to 15 bits. And with the ternary system we could represent numbers with up to ten ternary digits. In the decimal case we can represent the numbers from 0 to 999, that is 1000 numbers. In the binary case we can represent 2^{15} numbers, i.e. 32768 numbers. In the ternary case we can represent 3^{10} numbers, that is 59049 numbers. The ternary system is therefore almost twice as comprehensive as the binary system, using the same number of cardboards or "states", and almost 60 times better as the decimal system!

The ternary system allows also to use ternary logic in which the truth values are "true", "false" and "unknown". Logical operations can be defined that are more general that the binary logical operations. However, although the ternary system is more compact and more general logical operations are possible, the cost of ternary electronic components is much higher than the cost of binary elements. Binary computers are therefore more cost effective.

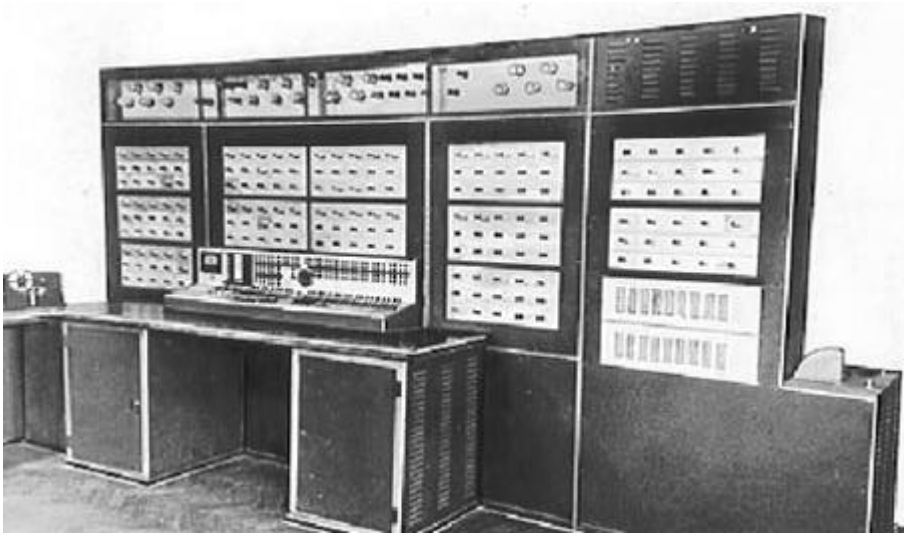
The SETUN computer, one of the few ternary logic systems ever built, was manufactured in a small series of 50 machines in the USSR. Thirty of the computers were used at Soviet universities. The machine was eventually discontinued.

References

Gerrit A Blaauw and Frederick P Brooks, Computer Architecture - Concepts and Evolution, Addison Wesley, Longman, 1997.

Knuth, Donald, *The Art of Computer Programming*, Addison Wesley, 1981.

Raul Rojas



Experimental "Setun" computer 1958