

Processors

Processors It is fairly easy to acquire a basic understanding of how a line of interlocking, 10-position gears can mimic the operations of decimal arithmetic. But it is far less obvious how an array of vacuum tubes or transistors, used as electronic on-off switches, mimic the operations of binary arithmetic.

One helpful analogy is that of a set of dominoes. Imagine a domino exhibition on a late-night talk show, where a domino champion sets up an elaborate maze of dominoes, knocks one of them over, and sets off an elaborate chain reaction of falling dominoes, lasting several minutes. Eventually, the sequence of falling dominoes reaches the end, and the last set of dominoes tumble over in a grand flourish. Similarly, imagine a set of dominoes on a table where there is a line of eight dominoes at one end, and another line of eight dominoes at the other end, with a maze of other dominoes in between. If you were to go to the eight dominoes at one end and knock over some or all of them, this would set off a chain reaction of falling dominoes in the maze laid out until, eventually, this chain reaction stopped at the other end where some or all of those eight dominoes would be knocked over as a result of this chain reaction.

There are some similarities here to the way a processor works. A domino, like a transistor, is a two state device: just as a transistor can be in either an on or off position, a domino can be either standing up or lying down. Thus, like any other two state device, a domino or transistor can model the two possibilities that exist for a binary digit: a 0 or a 1. For example, we could think of a domino that is standing up as a 1, and a domino that is lying down as a 0. Knocking over some or all of the dominoes in that first row of eight, then, is like "inputting" an eight digit binary number into this domino "machine."

This domino analogy provides many similarities to the way a processor chip made up of transistors operates. Binary numbers representing a basic arithmetic operation -- add, subtract, multiply, divide -- flow into a processor in the form of "high" or "low" electrical signals on wires. This sets off a chain reaction among the literally millions of microscopic transistors, on-off switches, that make up the processor. When the chain reaction has completed, a binary number representing the result flows out on the wires leading away from the processor. The maze of transistors within the processor is designed so that output of the chain reaction is the one that represents the "right answer" for the input arithmetic instruction. The Intel 8088, the processor used in the original IBM PC, in fact, was an 8-bit processor, meaning that, in the course of each instruction cycle, an 8-digit binary number would be input, the processing (chain reaction) would take place, and a resulting 8-digit binary number would be output.

Thus, even today, a modern electronic digital computer is still, at the core of its hardware, a machine that performs basic arithmetic operations. More specifically, it is a machine that mimics or models the way that digits change when humans do basic arithmetic. What is remarkable about the way that today's computers model arithmetic is their extraordinary speed in doing so. Today's microprocessors are typically 32 bits or higher, meaning that their instructions are comprised of binary numbers that are 32 or more digits. Their instruction cycles are described in "gigahertz," meaning that such processors can perform literally billions of instruction cycles every second.