

Each pixel of the animations or movies you watch, and each letter of the instant messages you send presents your computer with several hundred equations. Each equation must be solved in a few billionths of a second—if it takes a bit longer, you might complain that your computer is slow.

Early Computers The earliest computers could solve very complex arrays of equations, just as yours can, but it took them a lot longer to do so. There were several reasons for this. First, the mathematics of algorithms (problem-solving strategies) still was new. Computer scientists were only beginning to learn how to arrange a particular problem, such as the conversion of a picture into an easily-transmittable form, so that it could be solved by a machine.



UNIVAC 1, an early computer, filled an entire room.

Machine Size Second, the machines were physically large. Computers work by switching patterns of electric currents that represent binary numbers. A 16-bit machine works with binary numbers that are 16 bits long. If a 64-bit number must be dealt with, the machine must repeat the same operation four times. A 32-bit machine would have to repeat the operation only twice, thus making it that much faster. But a 32-bit machine is four times the size of a 16-bit machine; that is, it has four times as many wires and transistor switches, and even 8-bit machines were the size of the old UNIVAC shown above.

Moreover, current travels along wires at speeds no greater than about two-thirds the speed of light. This is a long time if the computer wires are 15 m long and must move information in less than 10^{-9} s.

Memory Third, electronic memories were extremely expensive. You may know that a larger memory lets your computer work faster. When one byte of memory required eight circuit boards, 1024 bytes (or 1 K) of memory was enormous. Because memory was so precious, computer programs had to be written with great cleverness. Astronauts got to the Moon with 64 K of memory in *Apollo's* on-board computers.



Processor chips used in today's computers are tiny compared to the old computer systems.

When Gordon Moore and others invented the integrated circuit around 1960, the size and cost of computer circuitry dropped drastically. Physically smaller, and thus faster, machines could be built and very large memories became possible. Today, the transistors on a chip are now smaller than bacteria.

The cost and size of computers have dropped so much that your cell phone has far more computing power than most big office machines of the 1970s.

Going Further

- 1. Research** A compression protocol makes a computer file smaller and less prone to transmission errors. Look up the terms *.jpg*, *.mp3*, *.mpeg*, and *.midi* and see how they apply to the activities you do on your computer.
- 2. Calculate** Using the example here, how long does it take for a binary number to travel 15 m? How many such operations could there be each second?