A History of the Electronic Digital Computer (part 1)

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Abstract

This paper is a slighted edited version of my paper originally published in the January 1997 issue of *Phasor* (pp. 4-8), a computer journal (in PDF) for the computer user group MACRO, which was defunct in mid-1997, IIRC. I was the editor of the journal during its very short run.

Introduction to the Series:

It is impossible to say who invented the concept of the modern computer. Indeed, its conception as a machine that can replace human mental labor and thought probably goes back to antiquity. However, we will take a look at the people who envisioned the first general-purpose computer and created machines toward that goal. We will look at those who are credited with building the first electronic digital general-purpose computer. There are hotly contested views here. For example, should credit for this go to Eckert and Mauchly or to von Neumann, or rather to Atanasoff? (All I can do is to present the evidence as it revealed itself to me during my research on it.) Lastly, we will look at the bizarre story of how the computer came into the home of the average American, and it had nothing to do with reverse-engineering alien technologies.

The electronic digital computer had its formal unveiling during World War 2, in which it was used to help break enemy codes and aim anti-aircraft guns onto target. There were other marvels of invention that came out of WW2: wonder drugs (beginning with penicillin), rockets, radar, atomic bombs. And, if we succeed in not blowing ourselves up in a nuclear holocaust, we can safely say that of all of these wonders, it is the computer that affects us the most.

It is interesting that what motivated the thinkers and inventors of the nineteenth century to conceive of and to build computing machines is not much different from those motives of modern computer makers: to perform accurate mathematical computations, to precisely control the movement of machine parts, to imitate human thought for philosophical implications, and to increase the speed and reduce the tedium of certain human tasks. In this series we will follow three seminal lines of development that laid the foundation for the digital computer and its modern descendants: Logicians and decision making, mathematicians and calculation, and engineers and machine control. We will see that the first person to put all these elements together in a computing machine was the engineer, Herman Hollerith, who created a machine to help analyze the results of the 1890 U.S. Census.

This coverage of the history of the digital electronic computer will be in a number of parts. The first includes the history up to about 1900. The second goes from 1900 to 1946. The rest will be divided up for other parts of the series. Through it we will see that one reason our software doesn't all work together is because their manufactures don't all get along. We will see that the market doesn't always go to the best or even the first. That often the belief that the computer can do anything you can image, and do it as if it were like magic, is more important than all the naysaying of so-called experts.

PART ONE

Computing machines up to 1900

The modern electronic general-purpose digital computer is the descendent of two very different kinds of non-electric computing machines: digital and analog. The analog machine can be typified by its first and most endearing example, that of the slide rule, which was invented by the English clergyman William Oughtred in 1621. The slide rule was based on the mathematical principle of the logarithm, which was invented by John Napier in 1594. The slide rule did multiplications and divisions using the analog method of the logarithm's continuous property. Analog actually refers to the use of some devise that imitates the continuous behavior of the system to be analyzed, thus the analog calculator is analogous to the actual system. The name "analog computer" appears to go back to the physicist John V. Atanasoff, who worked on building his own computer in the 1930s and 40s. (This person plays a pivotal role in the controversy on who invented the first electronic, digital, general purpose computer—but we'll get to that later.)

Several important mathematicians of the 17th and 18th centuries built calculating machines to aid computation in applied fields—from log tables to tax calculations. It goes without saying that being good with mathematics is a prerequisite for understanding how to build a machine to do calculation, and the prejudice to employing mathematicians on computer development and applications continued well into the 1960s. By this time, several high-level programming languages had been developed, and it was found to be possible to produce useful programs without being a math whiz.

The slide rule was not useful for additions and subtractions. A very old example of a device to aid in these computations is the abacus. But this device is clearly not using continuous motions, but rather the motions of discrete beads. This makes the abacus an example of a digital calculator. Both the slide rule and the abacus have slipped into near oblivion from their once vaulted positions.

The fall of the slide rule from its predominance hardly caught anyone's attention, though it had endured for over 350 years to the 1970s, well into the age of the modern computer. Of course it was the electronic pocket calculators that killed the slide rule. But they didn't take over until they were cheap, small, and portable. Nerdism had lost its principal symbol, and would have to rely all the more on its former runnerup—the pocket protector. In time, the hand-held electronic calculator will become the hand-held computer, and eventually the handheld tri-quarter.

Weaving Algebraic Patterns

The sixteenth through eighteenth centuries saw an enormous increase in new and difficult applied mathematics, but little improvement in the means of calculating machines to aid in the use of this new math.

The incentives for developing better computers in the 1800s were from two very different viewpoints. One viewpoint was that of the big governments who wanted better gunnery tables or better navigational tables. One such government, the English government, was willing to underwrite the cost of building machines that could help get these better tables to the people who needed them—for the good of the Empire, of course.

Another motivation to improve computing was to dominate a goods market. And the market our story focuses on is the textile market in France circa 1800. By this time the French textile market was already one of the best in the world. It used complicated looms to weave complicated patterns in the fabric. But the chore was tedious and subject to ruin because of human errors during the production. A man named Joseph M. Jacquard invented a new controlling mechanism that revolutionized the textile industry. His controlling mechanism stored the weave pattern for an entire fabric onto punched cards (some having as many as 24,000 cards). For every thread in the fabric the weave was determined by one card. Of course a large fabric needed many cards, but this trade off was far superior to the old system. Once the set of cards were made, they could be used over and over again.

The first person that history records as having conceived of an advanced computing machine on the modern model is Charles Babbage. His first attempt, the "difference engine," got its name from the function it performed, which was to produce tables of numbers formed from the difference of other numbers.

Babbage obtained financial backing from the English government in 1823. With this grant he was able to hire the skilled machinists to do the work of constructing new machine tools and designs. His design for the machine was revolutionary at the time: It had to be modular in design and print out its own result, again, to reduce errors by human translation.

Unfortunately, Babbage managed to sabotage his own effort to complete the project. No sooner had he decided on a plan of construction, then he thought up a better plan and told his workmen to drop what they had already done and to pursue this new project. I have no doubt that Babbage's revisions were real improvements, but the quixotic inventor fell into a trap: He had to have the ideal best, rather than just get something out the door that worked and was completed in a reasonable amount of time.

Babbage had underestimated the cost and sophisticated technology needed by his dream project. The work went slowly, and by 1827, after many personal hardships and disappointments, he took off to Europe to regain his direction in life. The next year he returned to England and took a prestigious office at Cambridge. Babbage decided to complete the difference engine. He applied for another government grant, and after a bit of haggling, got it. But now Babbage had some inheritance money to throw in, too.

This was not enough, though. The government was slow to reimburse his workers for their work. Babbage's chief machinist rebelled against the bad conditions, and left the project, taking all his valuable tools with him.[1] Babbage continued to work on the engine for another four years, then quit for good. The next year (1834) a simpler version of the difference engine was built by a Swedish engineer, named Georg Scheutz.

In spite of all Babbage's failures and his few detractors, he was an immensely respected scientist of his day. In 1828, he was appointed the Lucasian Professor at Cambridge, while he was yet in Rome. He threw great parties that entertained the scientific and literary elites of his day, including Darwin, Dickens, Herschel, and Longfellow.

On 5 June 1833, one of his guests was the seventeen-year-old debutante Augusta Ada, daughter of poet Lord Byron. She had been a lover of mathematics for many years prior, and she took an immediate interest in Babbage's work. Ada was a complete supporter of Babbage's new goal to complete work on a "Analytical Engine."

Babbage had clearly delineated the dual nature of the new machine. It would have a storage area and a memory area. Punch cards would be used to store data and programming instructions, or algorithms. He claimed that his idea for punch cards came from the Jacquard loom. Ada wrote the following of the comparison of the Analytical Engine to the Jacquard loom: "We may say most aptly that the Analytical Engine weaves algebraic patterns just as the Jacquard loom weaves flowers and leaves."

Unfortunately for the visionary Babbage, the technology of his day could not fulfil his dreams. Besides, the cost was too prohibited for his own finances to complete. With no other substantial backers to help out, he left the Analytical Engine in favor of completing a new and improved design to the Difference Engine. But this too would not be completed. Babbage died on 18 October 1871, and was soon forgotten. It is thanks to the writings of Ada that his work on the computer is remembered at all.

[1] We will see in this series that such in-house rebellions are common on these innovative technoloical adventures, and that those noted in this series of articles, who left their present employment to start up their own companies, contributed to the overall development of the modern computer.

Others's Contributions

George Boole is considered that Father of modern logic. In 1854, he published what is known today as Boolean algebra and it is the basis of computer decision theory.

By 1869, William Stanley Jevous built his "logic machine," capable of calculating in Boolean algebra.

During the 1870s, someone produced a bogus chess-playing machine. The fraud was eventually uncovered, but the desire to program a chess computer would continue right up to today. The implications for businesses to make money selling programs for entertainment is one motive, but another motive was to prove that machines can do things which are considered as requiring thought. This means that either we must re-think what we previously considered as being human thought or else allow that machines can think—at least at some rudimentary level. What computers can do challenges us at the philosophical level.

In the 1880s, Allan Marquand built a crude but effective logic machine, capable of solving short but humanly difficult logical syllogisms. Although his amazing machine was made of a wooden case and cat-gut innards, his real claim to fame was his schematic of an electrical circuit form of the logic engine, being perhaps the first example of an electrical logic machine. Marquand was inspired by the first-known design of an electrical switching circuit, drawn up by his former professor, Charles Sanders Peirce (logician and founder of "pragmatism" philosophical school of thought), and sent to Marquand in a letter.

In 1883, the astronomer John Couch Adams made a machine to solve differential equations. The particular significance of this accomplishment is that differential equations underlie most of the scientific description of physical phenomena in physics, chemistry, economics, astronomy, and so much more. Therefore, a machine that can solve simultaneous differential equations is a general-purpose machine, at least to scientists and economists. However, Adam's machine was analog, not digital, so it's becoming fully general is either impossible or unfeasible.

In 1890, a machine was invented to do statistics for biological and other scientific uses. But it wasn't long after that, that businesses started to use statistics to analyze its sales and inventory. The use of computers to analyze large data sets was the primary motive for early capitalizing of computer development by the private sector.

Herman Hollerith

The third line of development toward the digital computer was in engineering concern for accurate control of machinery. Of course, the key to making a control process work as an automated process lies in the control mechanism itself.

The engineer Herman Hollerith was motivated to build a machine to do the statistics for the Census Bureau while he was working for the agency. He met Dr. John Shaw Billings, who suggested to him that there should be a way to automate the whole thing. Later, Hollerith announced his solution in detail. Part of his design was to use punched cards to hold an individual's data. He claimed that the idea for the punch card came from railroad conductors punching holes into passenger tickets.

He built his machine, got patents on it, entered a contest to get his machine accepted by the Census Bureau, and won!

In 1896, Hollerith founded his Tabulating Machine Company, which was arguably the first computer company. Hollerith was an enormous success, and his company revolutionized American business.

In his later years, Hollerith found his health failing and his competition growing, not to mention his patents near termination. He met a man named Charles Flint who convinced him to merge his company with other companies to become the Computing-Tabulating-Recording Company, or CTR. On 1 May 1914, CTR hired Thomas Watson as its general manager. Ten years later Watson renamed CTR to International Business Machines, or IBM. The punch card was to be IBM's big profit maker for many decades after that. Hollerith died 17 November 1929.

William S. Burroughs

Our last story is of William S. Burroughs, who, in 1899, manufactured 50 business calculating machine intended to outdo even his best accountant, who could "mentally add four columns of figures at a time." He started this venture with two guiding principles: 1) it's got to do a better job than a human can do, 2) it will, as a result of that, sell well and make big profits. Unfortunately for Burroughs's first venture, he needed a third principle: 3) it's got to be easy for humans to use. Burroughs's machine was so difficult to use that only he and another employee were ever able to make it work to its design limitations. Burroughs recalled the poor machines and hid them in a closet, only later to take them out, carry them one-by-one to the window and drop them to the pavement below. Thus, started a metaphor used by TV advertisers for eliminating old or defective technology.

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