Charles Babbage and Ada Lovelace's Contributions

Charles Babbage was an English mathematician with experience working with various mechanical systems. He came up with the idea of a computer known as the "Difference Engine," later called the Analytic Engine. In concept, this machine would be able to automate the creation of various mathematical tables. Though he was unable to complete the machine himself, it marked a dramatic change to what machines were thought to be able to do.

During his time working on the machine, he worked closely with Ada Lovelace, who is considered to be the first computer programmer. She was commissioned to translate a paper written by Luigi Menabrea, who transcribed a lecture Babbage had given on the Analytic Engine in Geneva in French. As she was translating, she made many notes on the device, and ended up working with Babbage for roughly a year.

One of her key insights was the concept of representing various objects with numbers. In this way and according to rules, the Analytical Engine could be used to manipulate said objects. In her notes, she formulated a way of calculating Bernoulli numbers with the Analytical engine. While she was unable to prove this at the time, she was later proven to be correct when the early ENIAC was built. Ada Lovelace published her "Notes" describing the Analytical Engine in "Taylor's Scientific Memoirs" in 1843. In total, the work of Charles Babbage happened between the years of 1822, when he worked on a small model, up until his death in 1871. This work is significant to the world of computing and computer science as it provided a means of taking computational work from humans and into, somewhat in this case, easily manageable devices.

Herman Hollerith's Punch Card System

Herman Hollerith was an inventor who is considered the father of automatic computation. He was employed by the United States to work on the 1880 census. During this time, he found the process to be tedious and altogether liable to error. After some initial designs, he invented a tabulator and sorter that automatically punched holes into cards and then tallied the results, respectively. In 1890, he won a competition for the census that reduced the time required to do the census from an estimated 10 years down to only 3 months.

After this work, he went on to create other models of automated devices. In 1906 he introduced the "Type 1 Tabulator," a device that would allow the user to "program" it using an integrated wiring panel. He went on to work on various tabulating machines in his company that produced them. These devices were invented through the years of 1890 to 1949. The last tabulator like this was the IBM 407 Accounting Machine, which included high-speed, alphanumeric tabulation. It was marketed up until 1976.

The work of Herman Hollerith and his company in designing and developing punch card tabulators and sorters laid the groundwork of usable memory for computers. The punch cards were physical manifestations of automated tabulation that could be stored away and reused later.

The Turing Machine

The Turing Machine, named after its hypothesizer Alan Turing, is a hypothetical machine that Turing claimed could compute anything a human computer could do. As a hypothetical construct, the machine is said to operate with infinite memory wherein information and instructions can be stored. In form, it would contain the memory, a reader, and a writer. The machine would move through the memory (usually seen as a reel of tape) reading whatever ‘symbol’ was there and performing tasks based on it. Depending on the symbol, it would then write more symbols. The machine has a set of rules associated with it by which the symbols are understood, which can be seen as the program the machine is running. A simple example would be:

STATE	SCANNED SQUARE	OPERATIONS	NEXT STATE
a	blank	P[0], R	**b**
b	blank	R	**c**
c	blank	P[1], R	**d**
d	blank	R	**a**

This table of instructions says that the machine should start in state a, as it is at the top. If the reader reads a blank space in memory, then ‘print’ (p[x]) a 0 into memory and move right (R), then move onto state b. The following state, if the memory is blank, move right, step to state c. State c, if memory reads blank, print 1 to memory and move right, move to state d. In this final state, if memory is blank, then move right. As each place in memory is started as blank, this program will work to create a binary sequence of 010101... et cetera forever. Seen in this program are three of the four possible operations of the machine: Move right in memory one position (R), move left in memory one position (L), Print to memory X (P[X]) in the current position, and change state (Not seen here, but could be C[N] where N is the state).

Turing introduced this concept in his publication, ‘On Computable Numbers, with an Application to the Entscheidungsproblem’, published in 1936. His envisioning of this machine was pivotal in his creation of the machine he built called Bombe, a machine that was used to crack WWII German Enigma messages. Turing could not pursue his work on further machines very long due to the lack of technology at the time. Turing died in 1954, with his interests changing in 1951 to modeling biological growth.

Electronic Numerical Integrator and Calculator (ENIAC)

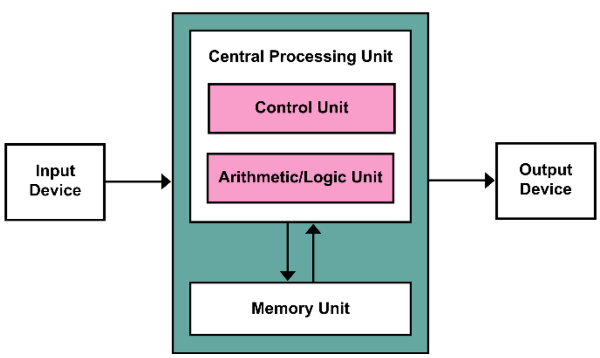
ENIAC, a hulking beast of digital, general-purpose computer. It was able to solve different problems through being reprogrammed, much like how Turing had described his Turing Machine. The work of creating ENIAC began in 1943 and was completed in 1945. The main purpose of the computer was for use by the U.S. military in order to create firing and bombing tables. After it's creation, it was programmed and operated by six female mathematicians, Jean Jennings, Marlyn Wescoff, Ruth Lichterman, Betty Snyder, Frances Bilas, and Kay McNulty. They *taught themselves* using only the blueprints and diagrams of ENIAC, then proceeded to write the *operating* manual.

The computer was comprised of some 18,000 vacuum tubes of varying types, 1,500 relays, 70,000 resistors, and 10,000 capacitors. The computer itself was 30 feet by 50 feet, weighing around 30 tons. Even back when it was being built, it cost around $500,000, around $7,906,560.69 in today's money at around 1481.3% inflation.

ENIAC was a significant production as no other digital computer had the speed or power as it did. All told, it was used by the military for a variety of calculations, from weather surveys to ballistics research.

Von Neumann Architecture

In 1945, John von Neumann et al. described a design for an electric, digital computer. In this description, they listed necessary components: A processing unit that contains an arithmetic logic unit (a circuit that performs arithmetic and bitwise operations on integer binary numbers) and process registers (storage areas that provide quick retrieval for the processor); a control unit with an instruction register (a storage area that holds what instruction is currently being performed) and a program counter (a register that stores "where" the computer is in the program); memory that stores both data (general information) and instructions (the operations that the processor can do); external mass storage (a hard-drive or tape where long-term information storage can be placed); and input (keyboard, mouse, trackpad, etc.) and output (monitor, printer, speaker, etc.) mechanisms. Together, these create the basis behind modern computers.



A simple image describing the general structure of the Von Neuman Architecture

This general structure, along with the ability to store instructions as data allows for low-level programs that further allow for higher-level languages like A, B, C, and C++. The use of these instruction sets creating runnable programs allows for assemblers (a program that makes somewhat human-readable code into even lower machine-code), compilers (a program that changes the language of one program into another language), linkers (a program that combines many different files into a single executable program), loaders (a system that loads required programs/instructions into memory to run a program), and others. These four base programs are what build the foundation of all current programming languages and allow for the vast amount of applications modern computers can be used for.

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