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

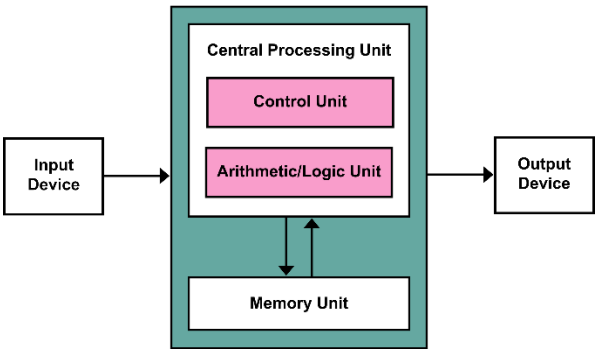
Machine. The work of creating ENIAC began in 1943 and was completed in 1945. The main purpose of the computer was for use by the U.S. military in order to create firing and bombing tables. After it's creation, it was programmed and operated by six female mathematicians, Jean Jennings, Marlyn Wescoff, 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 number of applications modern computers can be used for.

UNIVAC, the first commercial computer for business and government applications

UNIVAC, an acronym which stands for Universal Automatic Computer, was the world's first commercially produced electronic digital computer. The United States Bureau of the Census deemed the system as a versatile general-purpose machine, and they funded majority of the development. It was invented by Dr. Presper Eckert and Dr. John Mauchly in 1948. The first of this system was delivered to the Bureau in 1951. The device weighed 16,000 pounds, employed about 5,000 vacuum tubes and consumed about 125kW. It was able to perform 1,000 calculations per second. The system occupied around 382 square feet of floor space. It was also the first computer designed for business and administrative use. It had the ability to quickly execute arithmetic and data transport operations. UNIVAC was originally priced at $159,000 but eventually came to be sold between $1,250,000 and $1,500,000. 46 of the machines were built in total.

In 1952, the UNIVAC achieved national fame when CBS used the computer to predict Eisenhower`s unexpected landslide victory in the presidential election after just a small percentage of votes were in. Initially, CBS believed the computer had to be wrong with its prediction, so they considered it not working. As the final results of the election came in the UNIVAC came within 3.5% of the popular vote for Eisenhower and four votes for his electoral total, which CBS then admitted their wrong.

The significance of the creation of the UNIVAC brought many new technical innovations. It brought the magnetic tape, for example, for input and output. All machines developed prior to UNIVAC used either paper tape or cards for input and cards for output, which was a very slow method.

Invention of the Transistor

Before the transistor, in 1906, vacuum tubes were developed and used to amplify signals. AT&T bought the patent and attempted to improve it. The telephone company used the tubes to transfer singles on telephone lines across the country. However, the tubes were extremely unreliable, used too much power and produced too much heat. That’s when the invention of the transistor came in to change that.

A transistor, considered to be one of the most important inventions in history, is a semiconductor device used to amplify or switch electronic signals and power. It was invented by William Shockley, John Bardeen and Walter Brattain, who were all awarded with the Nobel Prize. In 1936, Shockley started working on the idea of the device and continued to for more than ten years but was not able to build a working model during those years. So, he called Bardeen and Brattain to take care of the engineering development of the device, which they were able to complete in just two years. The invention of the transistor was demonstrated on December 23, 1947 at Bell Laboratories in New Jersey.

The development of the transistors caused the vacuum tubes to eventually become obsolete. Transistors brought many and frequent advances to technology. In 1954, Texas instruments started commercial production of transistors for portable radios. Soon after, Sony began to produce transistors, as well and they came to dominate the market.

Grace Hopper and the First Computer Language

Grace Hopper, born in 1906 in New York City, is best known for her contributions to computer programming, software development and inventing the first programming language. She graduated with her bachelor's degree from Vassar College and then moved on to Yale University, where she earned her Masters and PhD in Mathematics. She taught at Vassar College, soon after. In 1943, she gave up her position as a professor to join the United States Navy. The following year she was promoted as lieutenant and assigned to the Bureau Ordnance Computation Project at Harvard University. There, she worked on producing the Mark I, an early prototype of the electronic computer. Hopper wrote a 500-page manual of operations for the Automatic Sequence Controlled Calculator where she outlined the fundamental operating principles of computing machines. She also coined the word "bug" which is described as a computer malfunction.

In 1949, she became a research fellow at Harvard. Harper was also involved in the invention of the UNIVAC. She then developed the first computer compiler, A-0, a program which translates mathematical code into codes that the computer can read. In 1953, she proposed the idea of writing programs in words instead of symbols.This allowed her to help develop COBOL, short for "common business-oriented language". It became the first standardized computer language. "It is a compiled English-like computer programming language designed for business use." COBOL allowed computers to respond to words and numbers and by the 1970s it was the most used computer language in the world. It was mainly used in business, finance, and administrative systems for companies and governments. It is still in use in applications onmainframe computers

Invention of Integrated Circuits

Prior to the first hybrid integrated circuit, which was created prior to the first monolithic integrated circuit demonstrated in 1960, there were ideas forming around the invention starting in 1949 when Werner Jacobi patented the first known integrated transistor amplifiers in 1949. A transistor, which is vital to integrated circuits, is a semiconductor device used to amplify or switch electronic signals and electrical power. This paves the way for us to give instructions to computers using binary system communication. More patents were created in the 1950s but it wasn't until 1958 and 1959 that big step forwards were achieved.

First, Jack Kilby invented a hybrid integrated circuit which is different from a monolithic integrated circuit in that a hybrid Integrated circuit is fabricated by inter-connecting a number of components a number of components on a substrate aka a printed circuit board instead of monolithic integrated circuits are fabricated in a series of steps entirely on a single wafer which is then diced into chips. In layman this means that the hybrid is installed with components as a

whole and more hard-wire interconnected than monolithic IC's, which are plugged into the motherboard more individually while still communicating with other components.

Shortly after Kurt Lehovec discovered p-n junction isolation, which is the method used to electrically isolate electronic components, such as transistors, on an integrated circuit by surrounding the components with reverse biased p-n junctions. Without this ability to isolate components via a insulating counter electrical charge, the components wouldn't be able to live in the same work environment (motherboard for example) without electrical issues.

Lastly, Robert Noyce, after these advances, was able to invent the first monolithic IC chip using improved insulation of components based on planar process, which is a process that builds individual components of a transistor and then connects the transistors together. A key component of the planar process that is also important for the length of the integrated circuits life span in way of surface passivation, which is a chemical coating technique used to make components less susceptible to environmental effects. Since the invention of this first monolithic IC, there have been many advances throughout the years, exponentially increasing their efficiency. But in the annals of history, Kilby and Noyce both share most of the credit for the invention of integrated circuits.

ARPANET

ARPANET aka the Advanced Research Projects Agency network was the first wide-area packet-switched network with distributed control and one of the first networks to implement the TCP/IP protocol suite. The former being a method of organizing data into packets prior to being sent from a source in a network to the desired receiver of said packet. Picture a file that is compressed into a header, which gives surface information to the contents of the packet, and a payload that contains the more detailed information that will later on be extracted by application software. An example in this that is pertinent to our class is sending in our MC challenges. Main_1.cpp was the header of our packet. The actual coding using the C++ language is extracted via our chosen program (VSCode, CS50IDE, etc.) to show the meat of the information that we are sending from one computer to the next.

The ARPANET project was initiated by Bob Taylor, who's contributions earned him awards including the National Medal of Technology and Innovation and the Draper Prize, in 1966. He proposed to his boss the ARPAnet, a network that will connect the different projects that ARPA was sponsoring. At the time, each project had its own terminal and special set of user commands. It wasn't until 1969 though, that computers were first successfully connected. One year later the Network Control Protocol was implemented. NCP being a protocol that used users email addresses to establish connections for all communications. It continued to expand in throughout the 70s and early to mid-80s and TCP/IP was installed in the ARPANET for production use in 1983 after the Department of Defense made it standard for all military computer networking. However, ARPANET, was decommissioned in 1990 after the introduction of a world-wide network, also known as the Internet.

UNIX Operating System

UNIX (Uniplexed Information and Computing Service) was born in the year 1969. Ken Thompson and Dennis Ritchie both worked at Bell Labs and were tired of using the Multics system. Multics (Multiplexed Information and Computing Service) was a time-sharing operating system that was being developed in the mid-1960s jointly by MIT, General Electric, and Bell Labs. While Multics did have innovative concepts that would later be used on more efficient technologies later on, Ken and Dennis thought that Multics was overly complicated in its format and clunky. So, they started to create an operating system that suited their needs. Their aim was to make UNIX a much more simple, easy, approachable, and inexpensive alternative to the predecessors.

It first saw light in the PDP-7 microcomputer. Innovation continued once implemented. Text-formatting and text-editing programs were added and in 1972, Dennis Ritchie wrote the C programming language that improved upon Ken Thompson's B language. Until this time, there were a very small amount of people with access to this indie adaptation of Multics. That would change drastically in 1974 when the duo published a CACM article about UNIX, it hit the internet was ablaze after hearing the praise that the Association for Computing Machinery had for this new system. Universities and start up companies were in love with the price point, simplicity, and amiability of this system. Source programs were readily available and easily modified online, allowing the program to evolve over time. It was a true tool for innovators, not to bogged down by financial barriers of entry.

Unix continued to soar and adapt into the 1980s into different variations, which led to some business difficulties, but dominated the operating system world for a long time. It wasn't until 1993 that Microsoft unloaded Windows NT operating system that innovatively competed with UNIX. After that UNIX had to share its space and Windows gained traction and later stole the spotlight. Both systems are still very prevalent today. Linux operating system, which began in 1991, was a kernel (computer program at the core of a computer's operating system that has control over everything in the system) based off of UNIX and still very popular today. Most, if not all operating systems to date, have taken something away from UNIX and its, at the time, revolutionary change of computers and how users can easily evolve the tech space through accessible, collaborative innovation.

The C Language

The programming language was developed between the years 1969 to 1972 alongside the development of the Unix operating system. Originally a Bells lab employee ken Thompson decided to make a language for the new operating system from the language BCPL later known as B. But because the language was slow and couldn't take advantage of some the full features of the operating system. Very few programs were ever written with it. This guided another Bells Lab employee Dennis Ritchie who restored features from BCPL and then created C.

Altair 8800

In 1974 Ed Roberts created the first commercially successful personal computer called the Altair 8800. When the Altair was created it had impacted the technology field greatly. It said it sparked the microcomputer revolution. Shortly after seeing the machine on the cover of an issue of Popular electronics Bill Gates and Paul Allen were influence greatly, they founded Microsoft on the possibilities that this machine could bring to field of technology. They set out to write the first programming language for the new machine. The language was called Altair BASIC.

'C with Classes' and C++

'C with Classes' is supposed to be a successor to the C programming language it was developed by Bjarne Stroustrup who started out working with The Simula 67 language which was the first language that to support project-oriented programming model. He saw the potential for object-oriented programming regarding software development. His goal was to add object-oriented programming to the C language. "His language included classes, basic inheritance, inlining, default function arguments, and strong type checking in addition to all the features of the C language."

The first compiler for the 'C with Classes' language was called Cfront. The cool think about Cfront is that the compiler itself was largely written with the "C with Classes" language making it a self-hosting compiler. It was later found that the compiler was difficult to use because there were challenges involved with implementing new features. Overall, the creation of the compiler was a steppingstone for "C with classes" language as well as the UNIX operating system.

In 1983 the language changed its to C++. The + + was an operator within the C language used to increment a variable like other languages such as Javascript. Other features were added to the language features such as virtual functions, function overloading is two of the more noteworthy features. Some features regarding commenting using double forward slashes. Within in two years in 1985 the creator Bjarne Stroustrup created a reference called The C++ Programming Language and within that same year C++ became a commercial product.

In 1990 the Borland Turbo's C++ compiler was released. Which allowed for many libraries were implemented, which granted further influence towards the continuing development of the C++ language. Within 1998 the first international standard for the C++ language was established was coined C++98. The annotated C++ Reference Manuel was a large influence in developing the standard at the time. The next standard was informally dubbed C + + 0x in 2005. The next standard wouldn't be released until the mid-2011. The Boost library project which is still being used as reference towards the standard C++ library today by the C++ Standards Committee adding additional support and sources. New features that were implemented are features such as regular expression support, a randomization library, a new C++ time library, as well as implementing a new for loop syntax.

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