History of Computing

Prehistory – the world before 1946

The word "Computing"

Originally, the word computing was synonymous with counting and calculating, and a computer was a person who computes. Since the advent of the electronic computer, it has come to also mean the operation and usage of these machines, the electrical processes carried out within the computer hardware itself, and the theoretical concepts governing them.

Prehistory: Computing related events

750 BC - 1799 A.D.

750 B.C. The abacus was first used by the Babylonians as an aid to simple arithmetic at sometime around this date.

1492 Leonardo da Vinci produced drawings of a device consisting of interlocking cog wheels which could be interpreted as a mechanical calculator capable of addition and subtraction. A working model inspired by this plan was built in 1968 but it remains controversial whether Leonardo really had a calculator in mind

1588 Logarithms are discovered by Joost Buerghi

1614 Scotsman John Napier invents an ingenious system of moveable rods (referred to as Napier's Rods or Napier's bones). These were based on logarithms and allowed the operator to multiply, divide and calculate square and cube roots by moving the rods around and placing them in specially constructed boards.

1622 William Oughtred developed slide rules based on John Napier's logarithms

1623 Wilhelm Schickard of Tübingen, Württemberg (now in Germany), built the first discrete automatic calculator, and thus essentially started the computer era. His device was called the "Calculating Clock". This mechanical machine was capable of adding and subtracting up to 6 digit numbers, and warned of an overflow by ringing a bell. Operations were carried out by wheels, and a complete revolution of the units wheel incremented the tens wheel in much the sameway counters on old cassette decks worked. Schickard was a friend of the astronomer Johannes Kepler since they met in the winter of 1617. Kepler used Schickard's machine for his astronomical studies. The machine and plans were lost and forgotten in the war that was going on, then rediscovered in 1935, only to be lost in war again, and then finally rediscovered in

1956 By the same man (Franz Hammer)! The machine was reconstructed in 1960, and found to be workable.

1642 French mathematician, Blaise Pascal built a mechanical adding machine (the "Pascaline"). Despite being more limited than Schickard's 'Calculating Clock' (see 1623), Pascal's machine became far more well known. He built around fifty, but was only able to sell around a dozen of his machines in various forms, coping with up to 8 digits.

1668 Sir Samuel Morland (1625-1695), of England, produces a non decimal adding machine, suitable for use with English money. Instead of a carry mechanism, it registers carries on auxiliary dials, from which the user must re-enter them as addends.

1671 German mathematician, Gottfried Leibniz designed a machine to carry out multiplication, the 'Stepped Reckoner'. It could multiply numbers of up to 5 and 12 digits to give a 16 digit result. The machine was later lost in an attic until 1879. Leibniz most important contribution to the computing era, however, was the binary number system which is used in all modern machines. He also co-invented calculus.

1726 (1735 ?) Johnathan Swift describes (satirically) a machine ("engine") in his Gulliver's Travels. The "engine" consists of a wooden frame with wooden blocks containing parts of speech. When the engine's 40 levers are simultaneously turned, the machine displays grammatical sentence fragments.

1774 Philip Matthaeus Hahn, somewhere in what will be Germany, also makes a successful multiplying calculator.

1775 Charles Stanhope, 3rd Earl Stanhope, of England, makes a successful multiplying calculator similar to Leibniz's.

1784 Johann H. Müller, of the Hessian army, conceives the idea of what came to be called a "difference engine". That's a special-purpose calculator for tabulating values of a polynomial, given the differences between certain values so that the polynomial is uniquely specified; it's useful for any function that can be approximated by a polynomial over suitable intervals. Müller's attempt to raise funds fails and the project is forgotten.

1800 – 1899 A.D.

1801 Joseph-Marie Jacquard developed an automatic loom controlled by punched cards.

1820 Charles Xavier Thomas de Colmar of France, makes his "Arithmometer", the first mass-produced calculator. It does multiplication using the same general approach as Leibniz's calculator; with assistance from the user it can also do division. It is also the most reliable calculator yet. Machines of this general design, large enough to occupy most of a desktop, continue to be sold for about 90 years.

1822 Charles Babbage designed his first mechanical computer, the first prototype of the decimal difference engine for tabulating polynomials.

1832 Babbage and Joseph Clement produce a prototype segment of his difference engine, which operates on 6-digit numbers and 2nd-order differences (i.e. can tabulate quadratic polynomials). The complete engine, which would be room-sized, is planned to be able to operate both on 6th-order differences with numbers of about 20 digits, and on 3rd-order differences with numbers of 30 digits. Each addition would be done in two phases, the second one taking care of any carries generated in the first. The output digits would be punched into a soft metal plate, from which a plate for a printing press could be made. But there are various difficulties, and no more than this prototype piece is ever assembled.

1834 Babbage conceives, and begins to design, his decimal "Analytical Engine". The program was stored on read-only memory, specifically in the form of punch cards. Babbage continues to work on the design for years, though after about 1840 the changes are minor. The machine would operate on 40-digit numbers; the "mill" (CPU) would have 2 main accumulators and some auxiliary ones for specific purposes, while the "store" (memory) would hold 1000 50-digit numbers. There would be several punch card readers, for both programs and data; the cards would be chained and the motion of each chain could be reversed. The machine would be able to perform conditional jumps. There would also be a form of microcoding: the meaning of instructions would depend on the positioning of metal studs in a slotted barrel, called the "control barrel". The machine would do an addition in 3 seconds and a multiplication or division in 2-4 minutes. It was to be powered by a steam engine.

1835 Joseph Henry invents the electromechanical relay.

1842 Babbage's difference engine project is officially cancelled. (The cost overruns have been considerable, and Babbage is spending too much time on redesigning the Analytical Engine.)

1843 Scheutz and his son Edvard Scheutz produce a 3rd-order difference engine with printer, and the Swedish government agrees to fund their next development.

1847 Babbage designs an improved, simpler difference engine (the Difference Engine No.2), a project which took 2 years. The machine could operate on 7th-order differences and 31-digit numbers, but nobody is interested in paying to have it built.(In 1989-91, however, a team at London's Science Museum did just that. They used components of modern construction, but with tolerances no better than Clement could have provided... and, after a bit of tinkering and detail-debugging, they found that the machine does indeed work. In 2000, the printer has also been completed.)

1848 British Mathematician George Boole devised binary algebra (Boolean algebra) paving the way for the development of a binary computer almost a century later. See 1939

1853 To Babbage's delight, the Scheutzes complete the first full-scale difference engine, which they call a Tabulating Machine. It operates on 15-digit numbers and 4th-order differences, and produces printed output as Babbage's would have. A second machine is later built to the same design by the firm of Brian Donkin of London.

1858 The first Tabulating Machine (see 1853) is bought by the Dudley Observatory in Albany, New York, and the second one by the British government. The Albany machine is used to produce a set of astronomical tables; but the observatory's director is then fired for this extravagant purchase, and the machine is never seriously used again, eventually ending up in a museum. The second machine, however, has a long and useful life.

1869 The first practical logic machine is built by William Stanley Jevons.

1871 Babbage produces a prototype section of the Analytical Engine's mill and printer.

1875 Martin Wiberg produces a reworked difference engine-like machine for preparing logarithmic tables.

1878 Ramon Verea, living in New York City, invents a calculator with an internal multiplication table; this is much faster than the shifting carriage or other digital methods. He isn't interested in putting it into production; he just wants to show that a Spaniard can invent as well as an American.

1879 A committee investigates the feasibility of completing the Analytical Engine and concludes that it is impossible now that Babbage is dead. The project is then largely forgotten, though

Howard Aiken is a notable exception.

1884 Dorr E. Felt (1862-1930), of Chicago, makes his "Comptometer". This is the first calculator where the operands are entered merely by pressing keys rather than having to be, for example, dialled in. It is feasible because of Felt's invention of a carry mechanism fast enough to act while the keys return from being pressed.

1885 A multiplying calculator more compact than the Arithmometer enters mass production. The design is the independent, and more or less simultaneous, invention of Frank S. Baldwin, of the United States, and T. Odhner, a Swede living in Russia. The fluted drums are replaced by a "variable-toothed gear" design: a disk with radial pegs that can be made to protrude or retract from it.

1886 Herman Hollerith uses his tabulating system in the Baltimore Department of Health.

1889 Dorr E. Felt invents the first printing desk calculator.

1890 The 1880 census had taken 7 years to complete since all processing had been done by hand off of journal sheets. The increasing population suggested that by the 1890 census the data processing would take longer than the 10 years before the next census - so a competition was held to try to find a better method. This was won by a Census Department employee, Herman Hollerith - who went on to found the Tabulating Machine Company, later to become IBM. Herman used Babbage's idea of using the punched cards from the textile industry for the data storage. His machines used mechanical relays (solenoids) to increment mechanical counters. This method was used in the 1890 census, the result (62,622,250 people) was released in just 6 weeks! This storage allowed much more in-depth analysis of the data and so, despite being more efficient, the 1890 census cost about double (actually 198%) that of the 1880 census. The inspiration for this invention was Hollerith's observation of railroad conductors during a trip in the western US; they encoded a crude description of the passenger (tall, bald, male) in the way they punched the ticket.

1892 William S. Burroughs of St. Louis, invents a machine similar to Felt's (see 1886) but more robust, and this is the one that really starts the mechanical office calculator industry.

1895 "Everything that needed to be invented is now invented.", Lord Kelvin, Royal Society of the UK.

1900 – 1939 A.D.

1906 Henry Babbage, Charles's son, with the help of the firm of R. W. Munro, completes the mill of his father's Analytical Engine, just to show that it would have worked. It does. The complete machine is never produced.

Electronic Tube (or Electronic Valve) developed by Lee De Forest in U.S.A.. Before this it would have been impossible to make digital electronic computers.

1919 W. H. Eccles and F. W. Jordan publish the first flip-flop circuit design.

1924 Walther Bothe builds the first AND logic gate - the coincidence circuit, for use in physics experiments, for which he receives the Nobel Prize in Physics 1954. CPU design will eventually make heavy use of logic gates, 40 years later.

1930 Vannevar Bush builds a partly electronic Difference Engine capable of solving differential equations

1931 Kurt Gödel of Vienna University, Austria, publishes a paper on a universal formal language based on arithmetic operations. He uses it to encode arbitrary formal statements and proofs, and shows that formal systems such as traditional mathematics are either inconsistent in a certain sense or contain unprovable but true statements. This result is often called the fundamental result of theoretical computer science.

E. Wynn-Williams, at Cambridge, England, uses thyratron tubes to construct a binary digital counter for use in connection with physics experiments.

1936 Alan Turing of Cambridge University, England, publishes a paper on "computable numbers" which reformulates Kurt Gödel's results (see related work by Alonzo Church). His paper addresses the famous `Entscheidungsproblem' whose solution is achieved by reasoning (as a mathematical device) about the theoretical simplified universal computer known today as a Turing machine, which in many ways is more convenient than Goedel's arithmetics-based universal formal system.

1937 George Stibitz of the Bell Telephone Laboratories (Bell Labs), New York City, constructs a demonstration 1-bit binary adder using relays. This is one of the first binary computers, although at this stage it was only a demonstration machine improvements continued leading to the 'complex number calculator' of Jan. 1940.

Claude E. Shannon publishes a paper on the implementation of symbolic logic using relays.

1938 Konrad Zuse of Berlin, completes the "Z1", the first mechanical binary programmable computer. It is based on Boolean Algebra and has most of the basic ingredients of modern machines, using the binary system and today's standard separation of storage and control. Zuse's 1936 patent application (Z23139/GMD Nr. 005/021) also suggests a `von Neumann' architecture (re-invented in 1945) with program and data modifiable in storage. Originally the machine was called the "V1" but retroactively renamed after the war, to avoid confusion with the V1 missile. It works with floating point numbers having a 7-bit exponent, 16-bit mantissa, and a sign bit. The memory uses sliding metal parts to store 16 such numbers, and works well; but the arithmetic unit is less successful, occasionally suffering from certain mechanical engineering problems. The program is read from punched discarded 35 mm movie film. Data values can be entered from a numeric keyboard, and outputs are displayed on electric lamps. The machine is not a general purpose computer because it lacks looping capabilities.

1939 John Vincent Atanasoff and graduate student Clifford Berry of Iowa State College (now the Iowa State University), Ames, Iowa, complete a prototype 16-bit adder. This is the first machine to calculate using vacuum tubes.

Konrad Zuse completed the "Z2" (originally "V2"), which combined the Z1's existing mechanical memory unit to a new arithmetic unit using relay logic. Like the Z1, the Z2 lacks looping capabilities. The project is interrupted for a year when Zuse is drafted, but then released.

Helmut Schreyer completes a prototype 10-bit adder using vacuum tubes, and a prototype memory using neon lamps.

1940 – 1949 A.D.

Jan, 1940 At Bell Labs, Samuel Williams and George Stibitz complete a calculator which can operate on complex numbers, and give it the imaginative name of the "Complex Number Calculator"; it is later known as the "Model I Relay Calculator". It uses telephone switching parts for logic: 450 relays and 10 crossbar switches. Numbers are represented in "plus 3 BCD"; that is, for each decimal digit, 0 is represented by binary 0011, 1 by 0100, and so on up to 1100 for 9; this scheme requires fewer relays than straight BCD. Rather than requiring users to come to the machine to use it, the calculator is provided with three remote keyboards, at various places in the building, in the form of teletypes. Only one can be used at a time, and the output is automatically displayed on the same one. On 9th September 1940, a teletype is set up at a Dartmouth College in Hanover, New Hampshire, with a connection to New York, and those attending the conference can use the machine remotely.

Apr 1, 1940 Konrad Zuse founds the world's first computer startup company: the Zuse Apparatebau in Berlin.

12 May 1941 Now working with limited backing from the DVL (German Aeronautical Research Institute), Konrad Zuse completes the "Z3" (originally "V3"): the first operational programmable computer. One major improvement over Charles Babbage's non-functional device is the use of Leibniz's binary system (Babbage and others unsuccessfully tried to build decimal programmable computers). Zuse's machine also features floating point numbers with a 7-bit exponent, 14-bit mantissa (with a "1" bit automatically prefixed unless the number is 0), and a sign bit. The memory holds 64 of these words and therefore requires over 1400 relays; there are 1200 more in the arithmetic and control units. It also featured parallel adders. The program, input, and output are implemented as described above for the Z1. Although conditional jumps are not available, it was shown that Zuse's Z3 is indeed a universal computer. The machine can do 3-4 additions per second, and takes 3-5 seconds for a multiplication. Its rather modern, programmable, binary design makes it the forerunner of today's computers (several later well-known machines such as ENIAC still used the decimal system).

Summer, 1942 Atanasoff and Berry complete a special-purpose calculator for solving systems of simultaneous linear equations, later called the "ABC" ("Atanasoff Berry Computer"). This has 60 50-bit words of memory in the form of capacitors (with refresh circuits -- the first regenerative memory) mounted on two revolving drums. The clock speed is 60 Hz, and an addition takes 1 second. For secondary memory it uses punch cards, moved around by the user. The holes are not actually punched in the cards, but burned. The punch card system's error rate is never reduced beyond 0.001%, and this isn't really good enough. (Atanasoff will leave Iowa State after the US enters the war, and this will end his work on digital computing machines.)

1942 Konrad Zuse develops the S1, the world's first process computer, used by Henschel to measure the surface of wings.

Apr, 1943 Max Newman, Wynn-Williams, Alan Turing and their team at the secret Government Code and Cypher School ('Station X'), Bletchley Park, Bletchley, England, complete the "Heath Robinson". This is a specialized machine for cipher-breaking, not a general-purpose calculator or computer but some sort of logic device, using a combination of electronics and relay logic. It reads data optically at 2000 characters per second from 2 closed loops of paper tape, each typically about

1000 characters long. It was significant since it was the fore-runner of Colossus. Newman knew Turing from Cambridge (Turing was a student of Newman's.), and had been the first person to see a draft of Turing's 1937 paper. Heath Robinson is the name of a British cartoonist known for drawings of comical machines, like the American Rube Goldberg. Two later machines in the series will be named after London stores with "Robinson" in their names.

Sep, 1943 Williams and Stibitz complete the "Relay Interpolator", later called the "Model II Relay Calculator". This is a programmable calculator; again, the program and data are read from paper tapes. An innovative feature is that, for greater reliability, numbers are represented in a biquinary format using 7 relays for each digit, of which exactly 2 should be "on": 01 00001 for 0, 01 00010 for 1, and so on up to 10 10000 for 9. Some of the later machines in this series will use the biquinary notation for the digits of floating-point numbers.)

Dec, 1943 The Colossus was built, by Dr Thomas Flowers at The Post Office Research Laboratories in London, to crack the German Lorenz (SZ42) cipher. It contained 2400 Vacuum tubes for logic and applied a programmable logical function to a stream of input characters, read from punched tape at a rate of 5000 characters a second. Colossus was used at Bletchley Park during WWII - as a successor to April's 'Robinson's. Although 10 were eventually built, unfortunately they were destroyed immediately after they had finished their work - it was so advanced that there was to be no possibility of its design falling into the wrong hands (presumably the Russians). One of the early engineers wrote an emulation on an early Pentium - that ran at half the rate!

Aug 7, 1944 The IBM ASCC (Automatic Sequence Controlled Calculator) is turned over to Harvard University, which calls it the Harvard Mark I It was designed by Howard Aiken and his team, financed and built by IBM - it became the second program controlled machine (after Konrad Zuse's). The whole machine is 51 feet long, weighs 5 tons, and incorporates 750,000 parts. It used 3304 electromechanical relays as on-off switches, had 72 accumulators (each with its own arithmetic unit) as well as mechanical register with acapacity of 23 digits plus sign. Unlike in Zuse's earlier binary machine, the arithmetic is still fixed-point and decimal, with a plugboard setting determining the number of decimal places. I/O facilities include card readers, a card punch, paper tape readers, and typewriters. There are 60 sets of rotary switches, each of which can beused as a constant register - sort of mechanical read-only memory. The program is read from one paper tape; data can be read from the other tapes, or the card readers, or from the constant registers. Conditional jumps are not available. However, in later years the machine is modified to support multiple paper tape readers for the program, with the transfer from one to another being conditional, sort of like a conditional subroutine call. Another addition allows the provision of plugboard-wired subroutines callable from the tape. Used to create ballistics tables for the US Navy.

1945 Konrad Zuse develops Plankalkuel, the first higher-level programming language.

1945 Vannevar Bush develops the theory of the memex, a hypertext device linked to a library of books and films.