A History of Computing Science

CSC101
Furman University
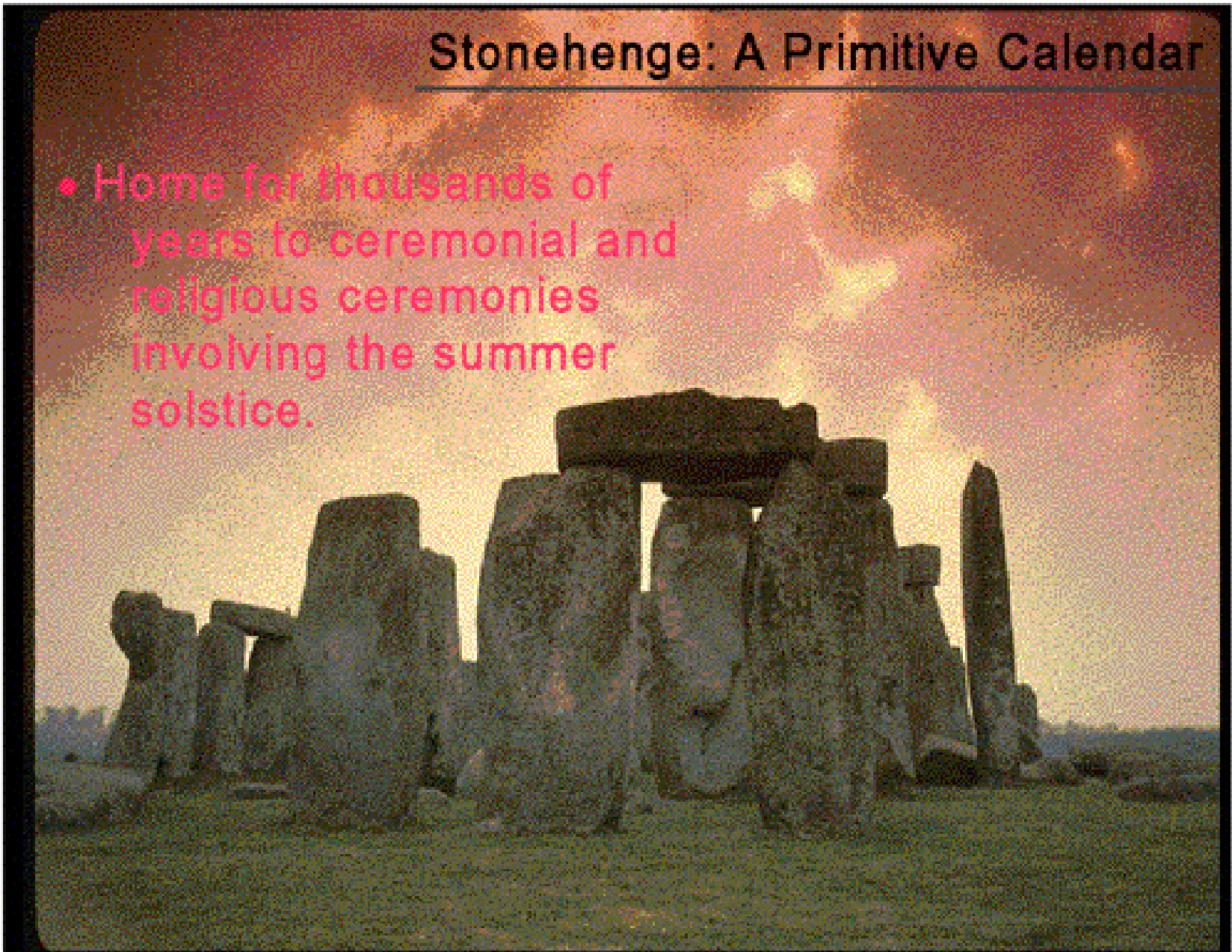**Professor Batchelor**

Counting: The Shaman

- Man started off by counting on his digits. He needed ways to measure the months and the seasons in order to perform religious festivals and ceremonies at the correct time.
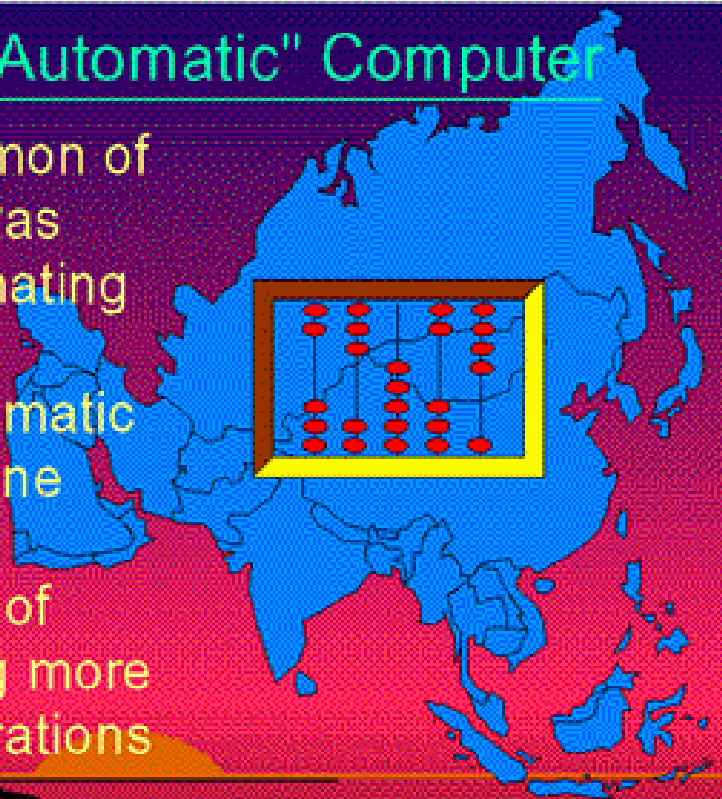
Stonehenge: A Primitive Calendar

- Home for thousands of years to ceremonial and religious ceremonies involving the summer solstice.
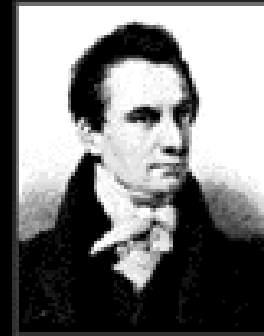
The Abacus: The First "Automatic" Computer

The abacus, the most common of which comes from China, was man's first attempt at automating the counting process. The abacus is not really an automatic machine; it is more a machine which allows the user to remember his current state of calculation while performing more complex mathematical operations than could be performed on hands and feet alone.

The First Mechanical Calculator

AaBbCcDdEeFfGgHhIiJjKkLlMmNn

Pascal's Gear System

A one-tooth gear engages its single tooth with a ten-teeth gear once every time it revolves; the result will be that it must make ten revolutions in order to rotate the ten-teeth gear once.

This is the way that an odometer works for counting kilometers. The one-tooth gear is large enough so that it only engages the next size gear after 1 km has passed.
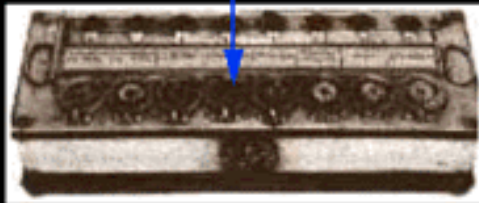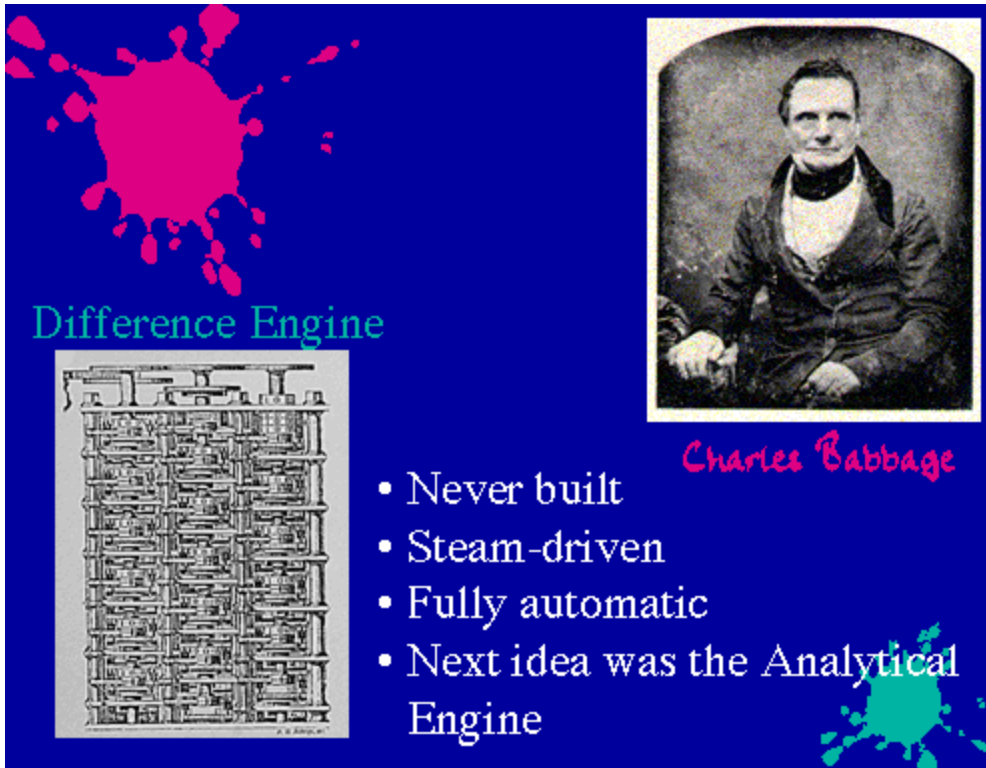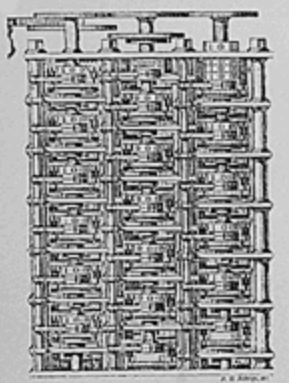
Pascal's Computer: The Pascaline

Blaise Pascal

The Difference Engine

Difference Engine

- Never built
- Steam-driven
- Fully automatic
- Next idea was the Analytical Engine

Charles Babbage

Charles Babbage

While Tomas of Colmar was developing the first successful commercial calculator, Charles Babbage realized as early as 1812 that many long computations consisted of operations that were regularly repeated. He theorized that it must be possible to design a calculating machine which could do these operations automatically. He produced a prototype of this "difference engine" by 1822 and with the help of the British government started work on the full machine in 1823. It was intended to be steam-powered; fully automatic, even to the printing of the resulting tables; and commanded by a fixed instruction program.

The Conditional
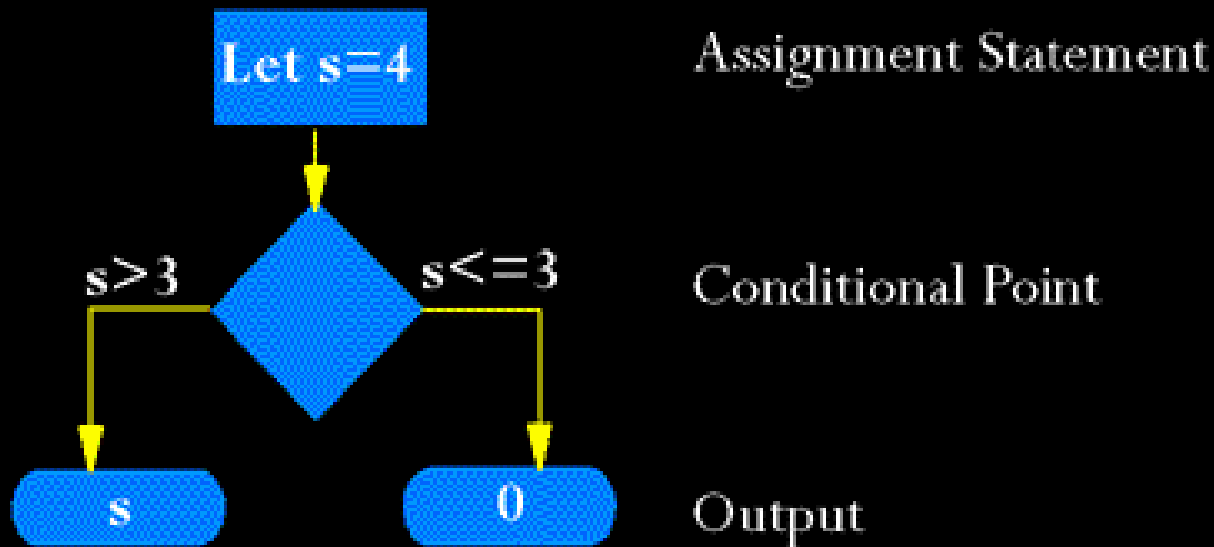
Herman Hollerith

Hollerith & Tabulating Machine

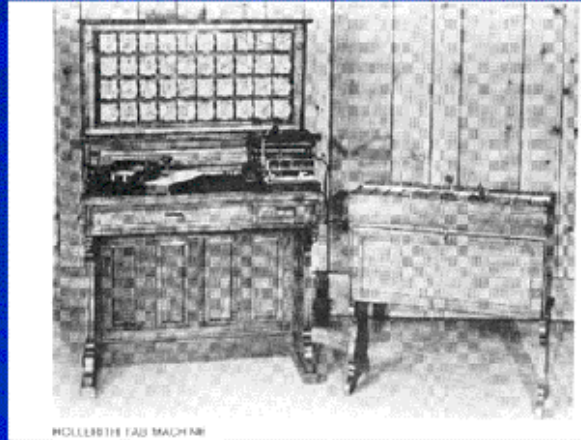This machine was so successful that Hollerith started a firm to market it which later became known as IBM.

A step toward automated computation was the introduction of punched cards, which were first successfully used in connection with computing in 1890 by Herman Hollerith working for the U.S. Census Bureau. He developed a device which could automatically read census information which had been punched onto card. Surprisingly, he did not get the idea from the work of Babbage, but rather from watching a train conductor punch tickets. As a result of his invention, reading errors were consequently greatly reduced, work flow was increased, and, more important, stacks of punched cards could be used as an accessible memory store of almost unlimited capacity; furthermore, different problems could be stored on different batches of cards and worked on as needed. Hollerith's tabulator became so successful that he started his own firm to market the device; this company eventually became International Business Machines (IBM).

Binary Representation

Hollerith's machine though had limitations. It was strictly limited to tabulation. The punched cards could not be used to direct more complex computations. In 1941, Konrad Zuse(*), a German who had developed a number of calculating machines, released the first programmable computer designed to solve complex engineering equations. The machine, called the Z3, was controlled by perforated strips of discarded movie film. As well as being controllable by these celluloid strips, it was also the first machine to work on the binary system, as opposed to the more familiar decimal system.

Binary Representation

The binary system is composed of 0s and 1s. A punch card with its two states--a hole or no hole-- was admirably suited to representing things in binary. If a hole was read by the card reader, it was considered to be a 1. If no hole was present in a column, a zero was appended to the current number. The total number of possible numbers can be calculated by putting 2 to the power of the number of bits in the binary number. A bit is simply a single occurrence of a binary number--a 0 or a 1. Thus, if you had a possible binary number of 6 bits, 64 different numbers could be generated. (2^(n-1))
Binary representation was going to prove important in the future design of computers which took advantage of a multitude of two-state devices such card readers, electric circuits which could be on or off, and vacuum tubes.

The Harvard Mark-I

Grace M. Hopper working on the Harvard Mark-I, developed by IBM and Howard Aiken. The Mark-I remained in use at Harvard until 1959, even though other machines had surpassed it in performance, providing vital calculations for the navy in World War II.

Alan Turing

Sample Turing Machine

Problem: Output a 1 if 3 or more ones in a row encountered; otherwise 0.

Read/Write head

1 0 1 1 1 0 1

Red lines represent input of 0

Blue lines represent input of 1

Green numbers represent output given current input.

State 3 — Start — State 1 — State 2
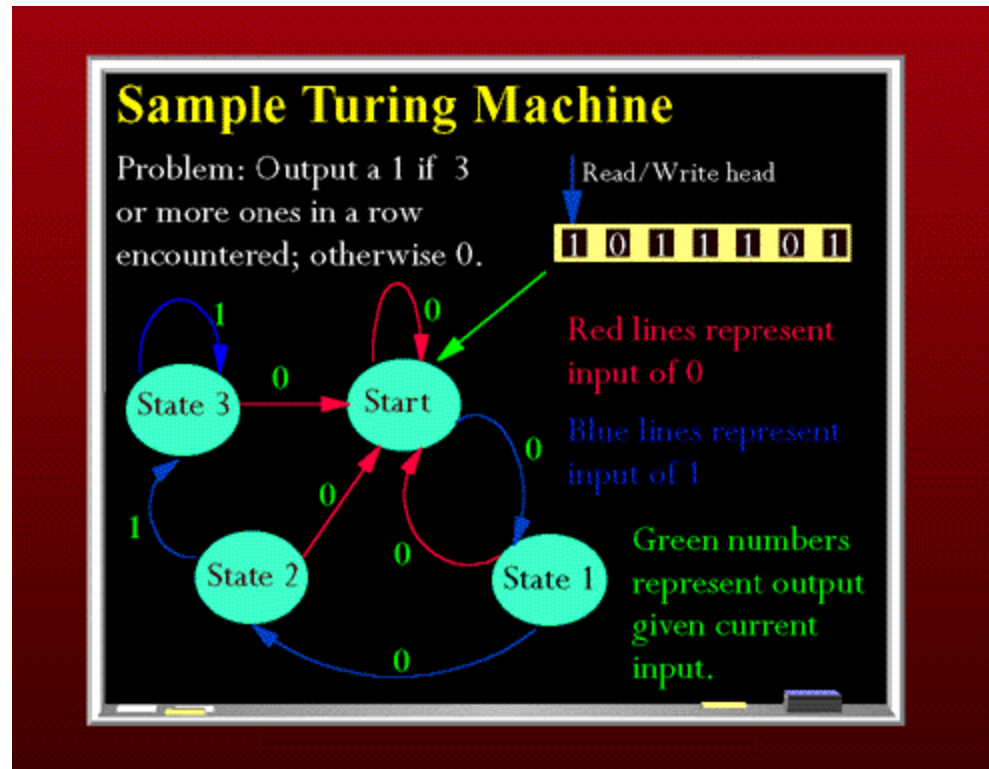
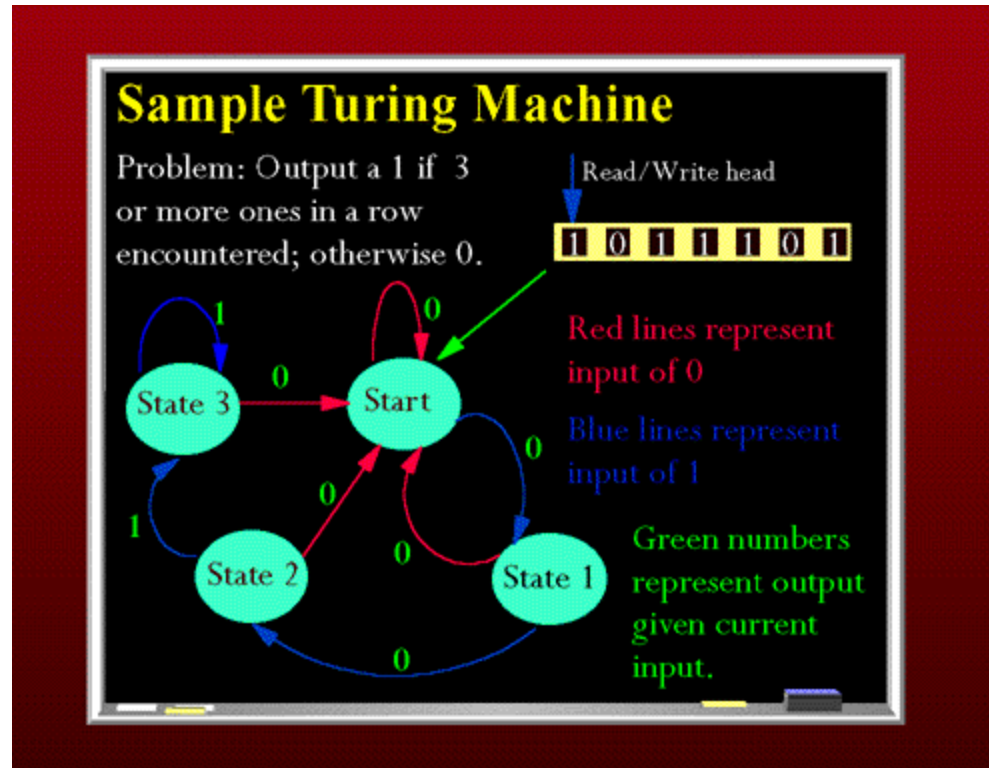Meanwhile, over in Great Britain, the British mathematician Alan Turing wrote a paper in 1936 entitled *On Computable Numbers* in which he described a hypothetical device, a Turing machine, that presaged programmable computers. The Turing machine was designed to perform logical operations and could read, write, or erase symbols written on squares of an infinite paper tape. This kind of machine came to be known as a finite state machine because at each step in a computation, the machine's next action was matched against a finite instruction list of possible states.

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The Turing machine pictured here above the paper tape, reads in the symbols from the tape one at a time. What we would like the machine to do is to give us an output of 1 anytime it has read at least 3 ones in a row off of the tape. When there are not at least three ones, then it should output a 0. The reading and outputting can go on infinitely. The diagram with the labeled states is known a state diagram and provides a visual path of the possible states that the machine can enter, dependent upon the input. The red arrowed lines indicate an input of 0 from the tape to the machine. The blue arrowed lines indicate an input of 1. Output from the machine is labeled in neon green.

The Turing Machine
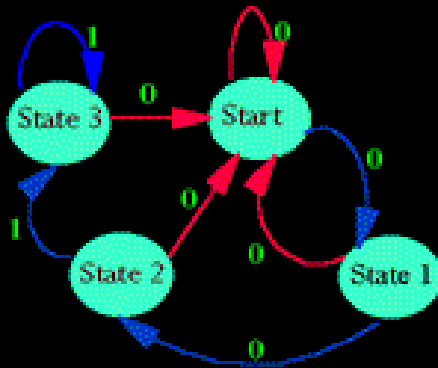
How It Works

- Input #1 is a 1. Machine moves into State 1 and outputs a 0.
- Input #2 is a 0. Since this doesn't help get three 1s in a row, go back to Start state.
- Input #3 is a 1; go to State 1.
- Input #4 is a 1, so go to State 2; output is 0.
- Input #5 is also a 1, so go to State 3; output is 1.
- Input #6 is a 0. No longer 3 or more ones; return to Start state; output is 0.
- Input #7 is a 1; go to State 1.

The Turing Machine

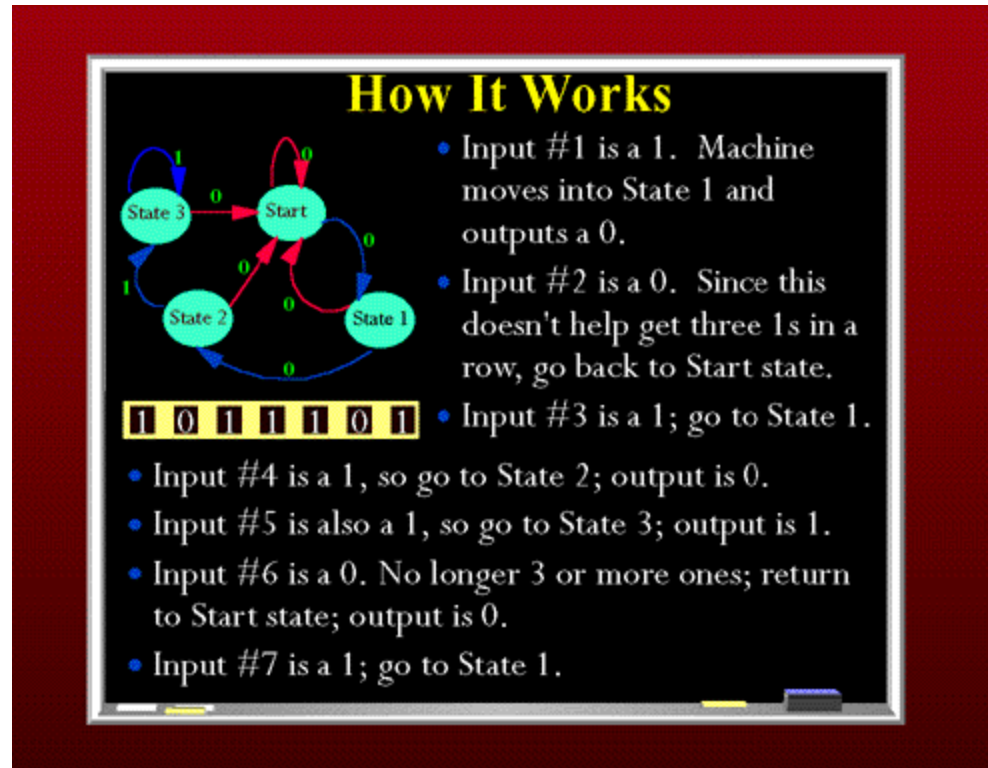## How It Works

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Turing's purpose was not to invent a computer, but rather to describe problems which are logically possible to solve. His hypothetical machine, however, foreshadowed certain characteristics of modern computers that would follow. For example, the endless tape could be seen as a form of general purpose internal memory for the machine in that the machine was able to read, write, and erase it--just like modern day RAM.
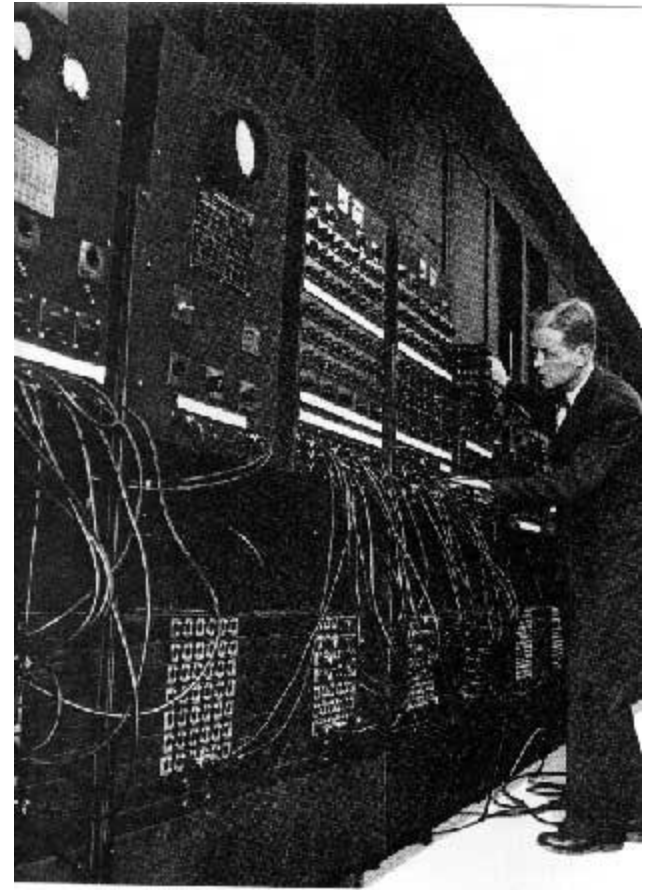
ENIAC

Back in America, with the success of Aiken's Harvard Mark-I as the first major American development in the computing race, work was proceeding on the next great breakthrough by the Americans. Their second contribution was the development of the giant ENIAC machine by John W. Mauchly and J. Presper Eckert at the University of Pennsylvania. ENIAC (Electrical Numerical Integrator and Computer) used a word of 10 decimal digits instead of binary ones like previous automated calculators/computers. ENIAC also was the first machine to use more than 2,000 vacuum tubes, using nearly 18,000 vacuum tubes. Storage of all those vacuum tubes and the machinery required to keep the cool took up over 167 square meters (1800 square feet) of floor space. Nonetheless, it had punched-card input and output and arithmetically had 1 multiplier, 1 divider-square rooter, and 20 adders employing decimal "ring counters," which served as adders and also as quick-access (0.0002 seconds) read-write register storage.
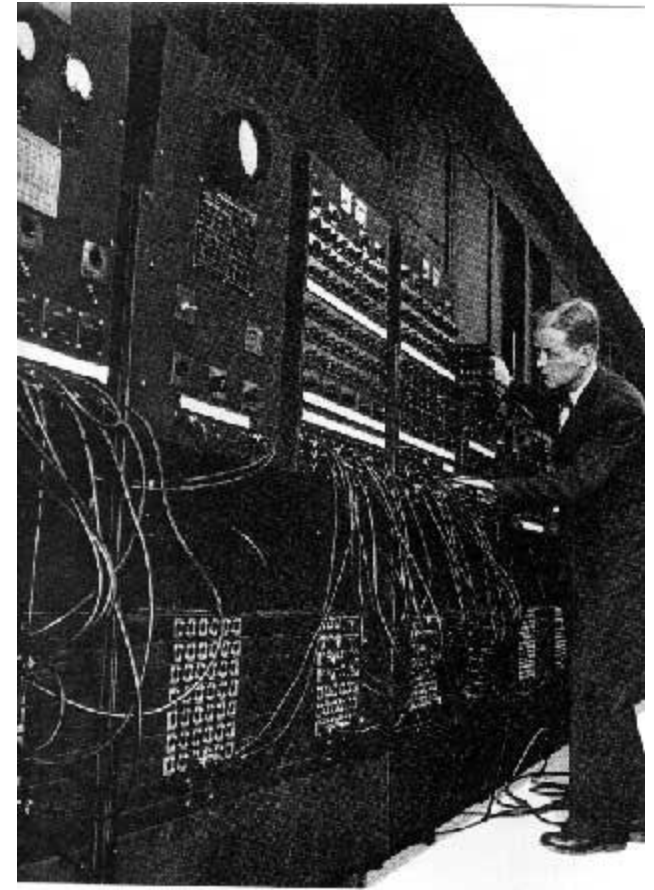
ENIAC

The executable instructions composing a program were embodied in the separate units of ENIAC, which were plugged together to form a route through the machine for the flow of computations. These connections had to be redone for each different problem, together with presetting function tables and switches. This "wire-your-own" instruction technique was inconvenient, and only with some license could ENIAC be considered programmable; it was, however, efficient in handling the particular programs for which it had been designed. ENIAC is generally acknowledged to be the first successful high-speed electronic digital computer (EDC) and was productively used from 1946 to 1955. A controversy developed in 1971, however, over the patentability of ENIAC's basic digital concepts, the claim being made that another U.S. physicist, John V. Atanasoff, had already used the same ideas in a simpler vacuum-tube device he built in the 1930s while at Iowa State College. In 1973, the court found in favor of the company using Atanasoff claim and Atanasoff received the acclaim he rightly deserved.

John von Neumann

Von Neumann: The Von Neumann Machine

- Data and program can be stored in the same space. Thus, the machine itself can alter either its program or its internal data.

- Conditional goto's to other points in the code.

- Von Neumann worked with Mauchly and Eckert on the design for EDVAC.

- Also a contributor to the fields of game theory and cellular automata.

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EDVAC

EDVAC (Electronic Discrete Variable Automatic Computer) was to be a vast improvement upon ENIAC. Mauchly and Eckert started working on it two years before ENIAC even went into operation. Their idea was to have the program for the computer stored inside the computer. This would be possible because EDVAC was going to have more internal memory than any other computing device to date. Memory was to be provided through the use of mercury delay lines. The idea being that given a tube of mercury, an electronic pulse could be bounced back and forth to be retrieved at will--another two state device for storing 0s and 1s. This on/off switchability for the memory was required because EDVAC was to use binary rather than decimal numbers, thus simplifying the construction of the arithmetic units.
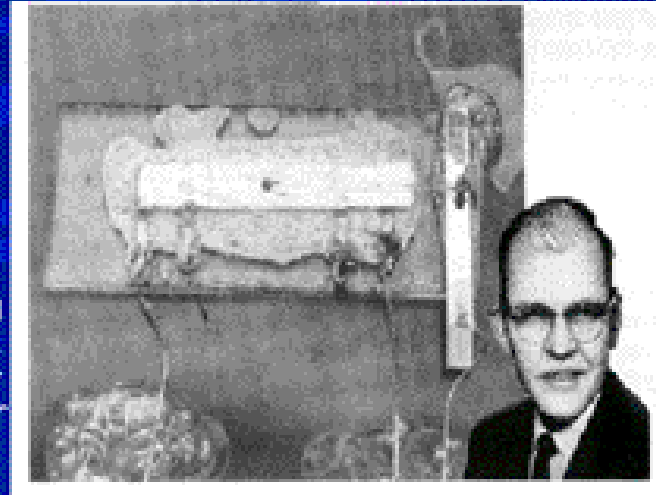
Technology Advances

Advances in the 1950's

Invented in 1947 by Shockley, Bardeen, & Brattain.

Invented in 1958 by Jack St. Clair Kilby.

Transistor

Integrated Circuit

- Freedom from vacuum tubes, which were extremely bulky.

- Allowed the placement of many transistors into a small area.

Both these advances enabled machines to become smaller and more economical to build and maintain.
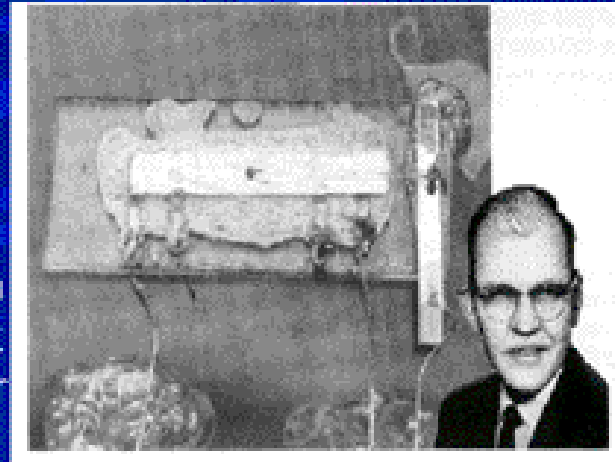
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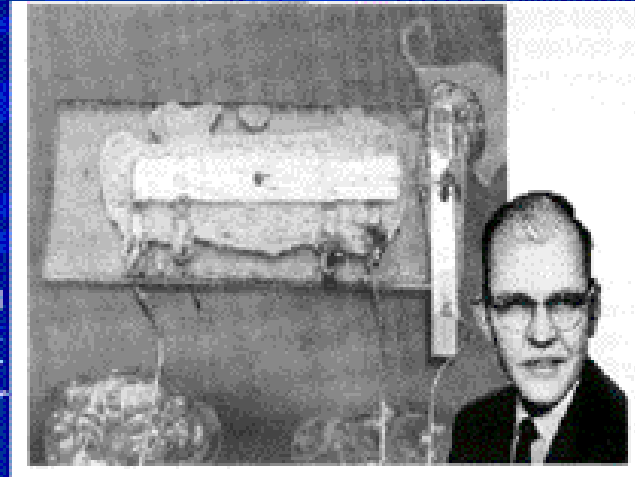
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In 1958, this problem too was solved by **Jack St. Clair Kilby** of Texas Instruments. He manufactured the first integrated circuit or chip. A chip is really a collection of tiny transistors which are connected together when the transistor is manufactured. Thus, the need for soldering together large numbers of transistors was practically nullified; now only connections were needed to other electronic components. In addition to saving space, the speed of the machine was now increased since there was a diminished distance that the electrons had to follow.

The Altair

In 1971, Intel released the first microprocessor. The microprocessor was a specialized integrated circuit which was able to process four bits of data at a time. The chip included its own arithmetic logic unit, but a sizable portion of the chip was taken up by the control circuits for organizing the work, which left less room for the data-handling circuitry. Thousands of hackers could now aspire to own their own personal computer.
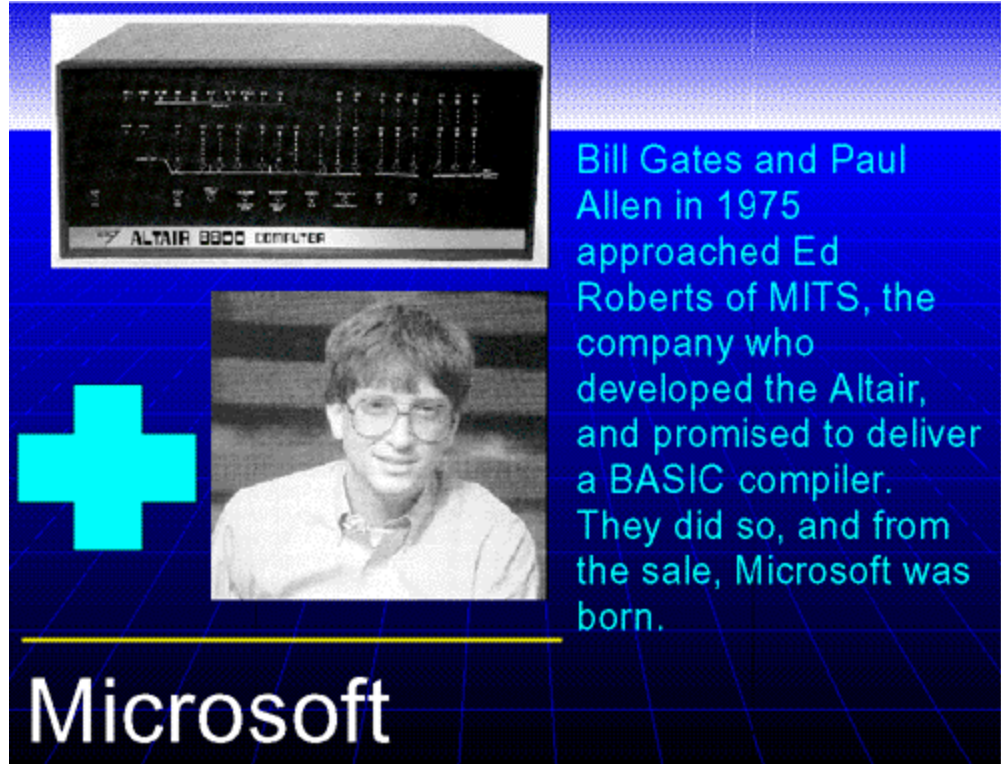

ALTAIR 8800 COMPUTER

Bill Gates and Paul Allen in 1975 approached Ed Roberts of MITS, the company who developed the Altair, and promised to deliver a BASIC compiler. They did so, and from the sale, Microsoft was born.

Microsoft

Computers up to this point had been strictly the legion of the military, universities, and very large corporations simply because of their enormous cost for the machine and then maintenance. In 1975, the cover of *Popular Electronics* featured a story on the "world's first minicomputer kit to rival commercial models....Altair 8800." The Altair, produced by a company called Micro Instrumentation and Telementry Systems (MITS) retailed for $397, which made it easily affordable for the small but growing hacker community.

The Altair

The Altair was not designed for your computer novice. The kit required assembly by the owner and then it was necessary to write software for the machine since none was yet commercially available. The Altair had a 256 byte memory--about the size of a paragraph, and needed to be coded in machine code- -0s and 1s. The programming was accomplished by manually flipping switches located on the front of the Altair.

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Creation of Microsoft

Two young programmers were intrigued by the Altair, having seen the article in *Popular Electronics*. They decided on their own that the Altair needed software and took it upon themselves to contact MITS owner Ed Roberts and offer to provide him with a BASIC which would run on the Altair. BASIC (Beginners All-purpose Symbolic Instruction Code) had originally been developed in 1963 by Thomas Kurtz and John Kemeny, members of the Dartmouth mathematics department.

BASIC & Other Languages

Other Computer Languages

FORTRAN

- FORmula TRANslator

- Used for science, math & engineering.

PASCAL

- Developed by Niklaus Wirth in the 60's.

- Disciplined approach to structure and data description.

COBOL

- COmmon Business Oriented Language

- Data descriptions stored separately from the program.

C   C++

- Derivative of ALGOL.

- It and its descendants very popular today for system programming.

Java

BASIC & Other Languages

In 1958, a group of computer scientists met in Zurich and from this meeting came ALGOL-- ALGOrithmic Language. ALGOL was intended to be a universal, machine-independent language, but they were not successful as they did not have the same close association with IBM as did FORTRAN. A derivative of ALGOL-- ALGOL-60--came to be known as C, which is the standard choice for programming requiring detailed control of hardware. After that came COBOL--COmmon Business Oriented Language. COBOL was developed in 1960 by a joint committee. It was designed to produce applications for the business world and had the novice approach of separating the data descriptions from the actual program. This enabled the data descriptions to be referred to by many different programs.

The PC Explosion

Following the introduction of the Altair, a veritable explosion of personal computers occurred, starting with Steve Jobs and Steve Wozniak exhibiting the first Apple II at the First West Coast Computer Faire in San Francisco. The Apple II boasted built-in BASIC, colour graphics, and a 4100 character memory for only $1298. Programs and data could be stored on an everyday audio- cassette recorder. Before the end of the fair, Wozniak and Jobs had secured 300 orders for the Apple II and from there Apple just took off.

The PC Explosion

IBM
- Acorn released under the unassuming name PC in 1981.
- 1984, 286-AT released.
- Whole host of clones introduced and Compaq releases a portable.

Apple
- Apple II, 1977.
- Apple III, 1980.
- Lisa, 1983; first machine with a mouse and graphical user interface.
- Macintosh introduced in 1984.

Other
- TRS-80 from Radio Shack, 1977.
- Commodore PET, 1980's.
- 1981, journalist Adam Osborne commissions design of Osborne I, which used CP/M.

Also introduced in 1977 was the TRS-80. This was a home computer manufactured Tandy Radio Shack. In its second incarnation, the TRS-80 Model II, came complete with a 64,000 character memory and a disk drive to store programs and data on. At this time, only Apple and TRS had machines with disk drives. With the introduction of the disk drive, personal computer applications took off as a floppy disk was a most convenient publishing medium for distribution of software.

The PC Explosion

IBM, which up to this time had been producing mainframes and minicomputers for medium to large-sized businesses, decided that it had to get into the act and started working on the Acorn, which would later be called the IBM PC. The PC was the first computer designed for the home market which would feature modular design so that pieces could easily be added to the architecture. Most of the components, surprisingly, came from outside of IBM, since building it with IBM parts would have cost too much for the home computer market. When it was introduced, the PC came with a 16,000 character memory, keyboard from an IBM electric typewriter, and a connection for tape cassette player for $1265.

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The PC Explosion

By 1984, Apple and IBM had come out with new models. Apple released the first generation Macintosh, which was the first computer to come with a graphical user interface(GUI) and a mouse. The GUI made the machine much more attractive to home computer users because it was easy to use. Sales of the Macintosh soared like nothing ever seen before. IBM was hot on Apple's tail and released the 286-AT, which with applications like Lotus 1-2-3, a spreadsheet, and Microsoft Word, quickly became the favorite of business concerns.

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That brings us up to about ten years ago. Now people have their own personal graphics workstations and powerful home computers. The average computer a person might have in their home is more powerful by several orders of magnitude than a machine like ENIAC. The computer revolution has been the fastest growing technology in man's history.

PCs Today

- Fast
- Graphical user interfaces (GUIs) allow you to use a mouse to control the computer
- Can run thousands of different sets of instructions (programs)

The Web

The Web can be used for:
- Looking up information on publications
- Shopping for books, computers, or CDs
- Investigating staff or research at universities.
- . Downloading pictures, games, or other files.

The Web (World Wide Web) was developed at the CERN lab in Zürich, Switzerland.

Requires a client program (such as Explorer or Mozilla) and a server to send information to the client