Machines that Think?
Electronic Computers

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Timeline for the Invention of Computers

- 5,000 years ago– Oriental Abacus
- 1617– John Napier and the system of logarithms
- 1642 to 1652– Pascal and his machine that adds and subtracts
- 17th Century– Leibniz and his machine, Stepped Reckoner
- 1822– Babbage and his “Difference Engine”
- 1847– Boole publishes “The Mathematical Analysis of Logic”
- 1854- Boole publishes “The Laws of Thought”
Timeline for the Invention of Computers (Continued)

• 1862– Charles de Colmar and his arithmometer
• 1880– Herman Hollerith creates a machine
• 1937– Claude Shannon combines Boolean Algebra with electrical relays
• Around 1937– Alan Turing invents the Turing machine
• 1941– Atanasoff and Berry make the Mark I
• 1943 to 1944– Tommy Flowers creates massive machine
• 1946– Eckert and Mauchly build ENIAC
• 1949 John von Neumann creates EDSAC
• Early 1950’s– invention of the transistor (second generation)
• Mid-19060’s– invention of integrated circuitry (third generation)
Location

- John Napier
- Pascal
- Leibniz
- Turing Machine
- Boole
- Difference Engine
- Mark I
- ENIAC
- EDSAC
The Beginning

- Computers did not come around until the middle of the 20th century
- They were large, slow, clumsy machines
- Often given the nickname “dinosaurs”
- There arose a need to make calculating more easy with the use of mechanical device
Oriental Abacus

- 5000 years ago
- A calculating device made up of beads and rods
- Also known as a counting tray or saunpan
Napier's Bones

- 1617, John Napier implemented a system of logarithms
- Using movable sticks numbered in a way that multiplication was done when sliding them in relation to one another
- William Oughtred, in 1630 improved on the idea inventing the slide rule which became well known until about a decade later
How to use Napier’s rods
Napier’s Multiplication

\[
\begin{array}{c}
46785399 \\
\times 96431 \\
\hline
46785399 \\
140356197 \\
187141596 \\
280712394 \\
+421068591 \\
\hline
4511562810969
\end{array}
\]
You Try!!

- 4659
- \( \times 43 \)
  \[
  \begin{array}{c}
  \times 43 \\
  13977 \\
  18636 \\
  \hline
  200337 \\
  \end{array}
  \]
Napier’s Division

\[
\begin{align*}
96431 & \quad 46785399 & \quad 96431 \\
192862 & \quad 385724 & \quad 485 \\
298293 & \quad 8212999 & \\
385724 & \quad 771448 & \\
482155 & \quad 498519 & \\
578586 & \quad 482155 & \\
675017 & \quad 16364 & \\
867879 & & \\
\end{align*}
\]
Blaise Pascal

- A brilliant mathematician designed and completed a machine between 1642 and 1652 at a very young age
- Named the *Pascaline*
- Like a car odometer, used the base ten principles and dials numbered 0 through 9
- Used for adding and subtracting
Difficulties

• Extremely tedious to make, just like clocks at the time
• Made by hand, one-by-one
• Hard to say if they were reliable since each gear, pivot, and other parts were done by hand
• So the precision was all in the abilities of the metalworker himself
Gottfried Leibniz

- One of the inventors of calculus
- Made an improvement on the *Pascaline*
- Made it so that it could multiply and divide
- Known as the *Stepped Reckoner*
- Advancement to the Pascaline because of its use of binary (base-two) arithmetic
- But craftsmanship of 1694 was not able to make reliable copies of the machine
Binary Place System

- Built on the idea of 0’s and 1’s relating to the electrical states of on and off
Decimal to Binary

- 0 - 0
- 1 - 1
- 2 - 10
- 3 - 11
- 4 - 100
- 5 - 101
- 6 - 110
- 7 - 111
- 8 - 1000
- 9 - 1001
- 10 - 1010
- 11 - ?
Try These...

- 11 - 1011
- 23 - 10111
- 44 - 101100
- 100 - 1100100
Charles de Colmar

• 150 years later
• Made an improved version of the *Stepped Reckoner* called the *Arithmometer*
• Won a gold medal at the 1862 International Exhibition in London
• Was successful into the 20th century due to the mass-production of the Industrial Revolution
Arithmometer

- Could multiply two 8-digit numbers in 18 seconds
- Divide a 16-digit number by an 8-digit number in 24 seconds
- And find the square root of a 16-digit number in one minute
- Really slow compared to today's devices, but really fast compared to hand calculation of the time
Charles Babbage

- Cambridge professor, early 19th century
- Worked on a machine that generated accurate logarithmic and astronomical tables
- Used for math, science, and navigation
- British government took an interest in his work
- *Difference Engine*
- With government backing Babbage continued to work and improve his machine but the spotlight was shifted
Joseph-Marie Jacquard

• 1801
• Designed a loom for weaving complex patterns, using a series of cards with holes punched in them
• Led Babbage to create a calculating machine that would read instructions from these punched cards
• Called the device *Analytical Engine*,
• Was steam-powered like the arising locomotives of the time
Augusta Ada Lovelace

- Assistant to Babbage
- Extended, translated and clarified a French description of Babbage's work, while adding a lot to it as well
- Expanded “programming” with the punched card system
- She wrote what is considered the first significant computer program
Babbage and Lovelace

• Lovelace went on to anticipate many of our modern advances of today like the “loop”
• But, the *Analytical Engine* was never built
• The technology of the metalworking age was not precise enough to meet the needs of the machine
• Their ideas were later rediscovered by some 20\(^{th}\) century computer designers
George Boole (mid-1800’s)

• Created two pieces of work that was the foundation for machine logic

• His two pieces were called:
  – 1) “The Mathematical Analysis of Logic” (1847)
  – 2) “The Laws of Thought” (1854)
  – These pieces explained the fundamental concepts of the process a machine works by using 1’s and 0’s, which is now called Boolean Algebra

• Boole thought that the boolean algebra he came up with would never work.
  – This actually was the key to the computer thinking process today.
Herman Hollerith (1880)

• Created a machine:
  – it sorted and arranged information that was previously recorded on punched cards.
  – The machine ran on electricity
• This machine cut the time of the 1890 census by 2.5 years.
• Founded Tabulating Machine Company
  – Later became known as IBM
Other important contributions to the invention of computers

- In 1937, Claude Shannon combined Boolean Algebra with electrical relays and switching circuits.
  - This showed how these machines could do mathematical logic.
- Alan Turing came up with a “Enigma Code”.
  - created many electronic machines to help in cryptanalysis.
  - This helped the British in World War II
- Alan Turing created the “Turing machine”
  - This helped figure out what kinds of problems computers can actually solve.
Computers used in World War II

- British mathematician Max Newman found a way to break the code of the computers that the Germans were using.
  - Problem: The process was slow and took a long time to do.
- Tommy Flowers then created a machine that decoded the messages that the Germans were sending.
  - decoded messages in hours, which was quicker than the weeks or months it took to decode by hand
  - Huge machine that used about 1500 vacuum tubes (used in radios).
  - Machine was named “Colossus”.
  - They made 10 of Flowers machines.
Konrad Zuse

• Created a programmable electronic computer around the late 1930’s and early 1940’s.
  – This gave him a little part of the claim to the title as the inventor of the electronic computer.

• War:
  – since war was going on, he had to keep his discovery on the down low.
John Atanasoff and Clifford Berry (1941)

- Berry was Atanasoff’s grad student at Iowa State.
- Created a computer that solved systems of linear equations.
First American Computer

- called Mark I
- created by Howard Aiken and a team of IBM engineers at Harvard University
- this machine used mechanical, electromagnetic relays
- it was 50 feet long and had about 800,000 parts
- Also, used more than 500 miles of wire
ENIAC (Electronic Numerical Integrator and Calculator)

• formed in February of 1946
• built by J. Presper Eckert and John Mauchly of the University of Pennsylvania
• created to help the U.S. war effort
• created for calculating naval artillery firing charts
  – Problem: the U.S. won the war without it
• very large machine
ENIAC (Continued)

• Design of machine:
  – 18,000 vacuum tubes
  – 1500 electrical relays
  – weighed more than 30 tons
• was 500 times more faster than the Mark I
  – used vacuum tubes more than mechanical relays
• wasn’t more reliable than Mark I
  – vacuum tubes burn out with use
John von Neumann and Eckert and Mauchly

- Neumann was credited with finding a way to store programs inside a computer.
- worked on EDSAC
  - Electronic Delayed Storage Automatic Computer
- Eckert and Mauchly:
  - formed a company that sold the first computer
    - called UNIVAC I (UNIVersal Automatic Computer)
- they sent one to the U.S. census bureau
The Upgrade of Computers

• Vacuum tube technology (first generation):
  – took up space and wasted a lot of power
  – didn’t have a lot of dependability

• Bell labs (second generation):
  – invented the transistor
    • allowed computers to be made smaller and more economical
    • allowed computers to be faster and more powerful
The Upgrade of Computers (Continued)

• Third generation:
  – introduction of integrated circuitry, in the mid-1960’s
  – personal computers became more affordable
• Over time, computers went from big computers to desktops to laptops to palmtops.
• Over time, computers gained more power, became faster, and had more memory space.
• Today, computers continue to upgrade!
Sources

- “Math through the Ages”, by William Berlinghoff and Fernando Gouvea