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Biographical info:

Charles Babbage is one of the most important figures of computing history and today recognized as a leader of the basic principles of modern computer structure. “Although there was some level of uncertainty, it is believed that he was born in London in 1791 as a son of a wealthy banker.”¹ Some resources are more specific about his birthday and location. “One of these resources state that Babbage was born December 26, 1792, to a banker in Totnes, Devonshire, England.”² Babbage, who was also a very successful mathematician, had an enormously productive scientific life style. The main reason of this scientifically productive life style, which allowed him to purely focus on his projects, was his financial stability. Thanks to the inheritance of his family, he didn’t have to get a job that pushed him to spend his valuable time and destruct his concentration for his projects. Although he had many failures, his plans and projects were highly advanced. Because of these plans and projects, he was considered as an inventor who was ahead of his time. His inventions and perspectives opened new doors for many other new generation scientists. The main purpose of this paper is to sufficiently cover the life and the projects of Charles Babbage, who is an unforgettable personality of computing history.

Charles Babbage had a very cheerful childhood. He had a large family with many sisters and brothers who provided him a loving family environment. In addition, during

¹ Williams, R. Michael, *A History of Computing Technology* (second edition), Los Alamitos: IEEE Computer Society Press, 1997. (Page: 154).

² “Charles Babbage,” http://www.all Sands.com/History/Objects/babbagecomputer_yy_gn.htm

his childhood, Babbage was always considered as an unhealthy child. The main reason of this was his appearance. He never gave people a strong healthy looking impression. “After changing many schools, he attended Forty Hill.”³ During the early years of his education, he was a problematic student. Yet he was not lazy. He always got involved with some activities. In addition, he developed different spiritual beliefs about religions. These beliefs were not mature at that age but they later became solid basis for his perspective about religions and spiritual concepts. In order to prepare his son for high ranked colleges, Babbage’s father pushed him to study grammar and philosophy. But the focus of Babbage was different. As soon as he had spare time, he read about mathematics.

After finishing the elementary school, Babbage’s attended Cambridge University. He was nineteen years old. During his college years, he proved to be a very social person by becoming member of a many different groups like Ghost Club and Extractors Club. Along with these student groups, he got involved with many types of different student activities. He kept this social attitude and continued to heavily interact with people during the early years of his life. In Cambridge, his relations with teachers were not very productive. He actually thought that these teachers had very little knowledge of mathematics and were not open to new changes. The differences between his views and the teachers of Cambridge mathematics department encouraged him to take an action. So, he established the “Analytical Society”. This new student group criticized Newton’s principles and his methods, which were more popular in the department. Instead of Newton’s teaching methods, this group preferred Leibnitz’s methods. That is why they tried to influence the department to accept Leibnitz’s methods. The Analytical Society

³ “Charles Babbage,” http://www.all Sands.com/History/Objects/babbagecomputer_yy_gn.htm

also focused on different subjects like detailed astronomical and navigational calculations. During these activities, Babbage witnessed the high possibility of errors in calculations. Because of these experiences, he began to dream about an automated calculation system. He almost simultaneously began to collect more information and focus on existing solutions for calculation errors. He quickly found out that there was not even one machine or method, which completely eliminate all calculation errors. All available machines had some failures. This situation helped him to develop his ideas. At the beginning of his career, automated calculation was not the only interest of Babbage. He had many different interests about many different topics.

In fact, throughout his career he focused on many different scientific issues, made researches and published articles and papers. “Most of these articles and papers were related to optics, atmospheric observations, cryptography, geology, metalworking, taxation systems, the operation of lighthouses, and the design of diving bells; Other than these papers and articles, he wrote books, which focus on the Economy of Machinery and Manufacturers.”⁴ This wide range of interest brought him a rich intellectual knowledge base and a strict discipline of academic studies. This intellectual knowledge base and strict discipline of academic studies motivated him to be more precise and accurate in his own findings too. This passion for accuracy caused him to focus on the ways of improving calculation techniques. This interest of Babbage pushed him to work on calculating machines. As a result, these machines became the most important inventions

⁴ Williams, R. Michael, *A History of Computing Technology* (second edition), Los Alamitos: IEEE Computer Society Press, 1997. (Page: 154).

of his life. “In addition, he was one of the most important members of the Royal Astronomical Society and was also a founder of the Royal Statistical Society”⁵

During the development process of his projects, Babbage faced many difficulties. Most of these difficulties were related to the financial limitations, which were created by the lack of continuous government support. Although he had powerful friends, he was not very successful in influencing the government policies towards his projects. During his life he traveled a lot. He especially loved and visited Italy many times. He passed away in London, England on October 18, 1871.

The major projects of Babbage and his achievements are deeply analyzed in the next part of this paper.

Major Works:

The life of Charles Babbage has many important turning points that rotated and shaped the content of his work. Most of these turning points and changes of his interest are caused by his deep curiosity and his passion. Automated calculation, which allows error free results, was his main passion.

This passion for automated calculation was directly related to his experience as a mathematician. “In Babbage's time, teams of mathematicians working around the clock with primitive calculations generated complex logarithmic and trigonometric tables manually; ... noting the large number of errors in these tables, Babbage proposed

⁵ Williams, R. Michael, *A History of Computing Technology* (second edition), Los Alamitos: IEEE Computer Society Press, 1997. (Page: 154).

building an enormous mechanical calculator.”⁶ This project became one of the most famous projects of Babbage and is called “Difference Engine”. Another main project that Babbage worked on is his “Analytical Engine”. This project was based on the first engine that he created.

Difference Engine:

The Difference Engine was the first attempt of Babbage to improve the accuracy of mathematical calculations. This idea was attracting his attention since the early years of his college education. His main goal was to build a very powerful machine that would allow very accurate calculations. These calculations were very important and necessary because calculation mistakes created disasters in many different parts of daily life. A good illustration of this is the necessity of obtaining accurate calculations for sailors. Because of the miscalculations of many captains and the lack of an accurate measurement tool, ships were sinking. Another example of this problem was the calculations of astronomers. They urgently needed better ways of measuring and calculating in order to be more precise in their explorations.

Babbage’s machine was the perfect solution for all these problems. “This machine was able to create tables of values by using the common difference between terms in the sequence.”⁷ It would also have a capability to print out. This feature was highly important in terms of decreasing the level of human errors, which occurred during data transfer. In 1819, he began to seriously plan this new machine. After couple of years (in 1823), he created a working prototype that was functioning properly and presented it to the Royal

⁶ Accardi, Joe, “The Difference Engine: Charles Babbage and the quest To Build the First Computer,” *Library Journal*, Volume 126, Issue 14, Sep 1, 2001, Page 215.

⁷ “Charles Babbage,” http://www.all Sands.com/History/Objects/babbagecomputer_yy_gn.htm

Astronomical Society. “He explained how the *Difference Engine* was capable of calculating successive terms of the sequence $n^2 + n + 41$ and reported in his research paper, “The terms of this sequence are 41, 43, 47, 53, 61... while the differences of the terms are 2, 4, 6, 8... The difference engine when given the initial data as 2, 0, 41; it constructs the next row 2, (0 + 2), (41 + (0 + 2)), that is 2, 2, 43; then the row 2, (2 + 2), (43 + (2 + 2)), that is 2, 4, 47; then 2, 6, 53; then 2, 8, 61...” – thus, he narrated how the engine was capable of producing the members of the sequence $n^2 + n + 41$, at the rate of about 60 every five minutes!”⁸ All this disciplined and organized work paid off, and he received a gold medal from the Astronomical Society for the success of his interesting project. Furthermore, government accepted his idea and made a request for the real version of the Difference Engine. Babbage didn’t lose time and began to work on the final product.

Unfortunately, the development of the real Difference Engine took very long time and generated high expenses. The main reason of this situation was the working habits of Babbage and his passion for more improvements. He constantly changed the plans and made new modifications all over the machine. These changes and modifications were usually related to the minor parts of the prototype. He spent all his time and money reinventing and redesigning the parts, which were already completed. Although many institutions including the Astronomical Society supported the development of his projects and tried to positively influence the government for more financial support, Babbage had hard time to fund his workshop. Most of the time, he had to use his own resources due to the cash flow problems. Even if government promised some kind of further financial help, it usually took time to cash it. This situation constantly destroyed the speed of his

⁸ “Charles Babbage,” <http://top-biography.com/9090-Charles%20Babbage/>

project and decreased his motivation. In addition, he had to constantly change his team. As in the absence of continuous work, many skilled workers left the workshop. Even though Babbage quickly hired new workers, they were not skilled enough and he had to teach them everything all over again.

During the process of designing this interesting machine, Babbage also had another problem. He was working with a partner, who was a highly skilled mechanic. His name was Samuel Clement. “Clement was one of the finest workmen of the day and Babbage relied on him for almost all the practical work on project.”⁹ Although their partnership was working fine, an important problem occurred. Babbage wanted to move the location of the workshop because he was tired of traveling. Clement didn’t accept this idea due to his responsibilities for his own customers. Because of this situation, Babbage lost the drawing and completed parts. According to the laws of that time, mechanic has the rights to the all products that they work on. So, Clement officially owned the plans and the drawings of the Difference Engine.

This discouraged Babbage to continue to work on this project. The Difference Engine was never completed.

Analytical Engine:

The Analytical Engine was the second important project that Babbage designed. The main idea behind the creation of this sophisticated machine was to build a powerful adding machine that is able to perform many functions all together. The idea was very

⁹ Williams, R. Michael, *A History of Computing Technology* (second edition), Los Alamitos: IEEE Computer Society Press, 1997. (Page: 165).

attractive and ahead of its time. Analytical Engine is actually the first machine that used the fundamentals of modern computers.

In order to realize his project, Babbage used a new and a different technology. At that time punched cards were used in some industries. He saw the power of these cards and decided to use them for his project. The most important advantage of these cards was the capability of programming. Any type of mathematical formula could be punched on these cards and used as different functions of the machine. In other words, depending on the requirements of the necessary calculations, different types of cards could be temporarily placed into the machine to manipulate the calculations of the Analytical Engine. This process of calculation also eliminated the necessity of a highly skilled operator. Whoever operates the machine, there was a little possibility to make mistakes. This idea actually created the first computer program. Codes that were punched on the cards were able to loop, or create conditional statements.

In fact, Analytical Engine can be considered as the first example of a modern computer. Its features and structure was completely different than any other machine of its time. The system of this machine includes many components like input devices, processor, storage, and output devices. “Babbage envisioned an input device, **the store** [a memory unit], **the mill** [a central processing unit], **the control**, and an output device – the basic elements of the present-day computer.”¹⁰ All these components are able to create a machine that provides accurate answers for any kind of calculation. But Babbage still had serious financial problems.

Although he tried to find more support, he could not find the desired attention. Analytical Engine was never completed. “In 1991, The National Museum of Science and

¹⁰ “Charles Babbage,” <http://top-biography.com/9090-Charles%20Babbage/>

Technology in London had specially built a computer using Babbage's designs and parts available to him during his time."¹¹

Analytical Engine is the most important work of Babbage. By designing this machine, he proved to be one of the first inventors of the modern computers.

Timeline:

Life of Charles Babbage is full of important discoveries and inventions. In addition, he has a famous reputation for social life. This part of the paper states all these social and scientific activities of Charles Babbage. The timeline which is presented here in this part of the paper was mostly created by using the info provided by three websites. (<http://top-biography.com> , <http://ei.cs.vt.edu> and <http://www-groups.dcs.st-andrews.ac.uk>).

1791 - Charles Babbage was born in London, England on December 26th.

1810 - He studied Mathematics at the Trinity College, Cambridge.

1812 - He established the Royal Analytical Society.

1814 - He graduated with a B. A. from Peterhouse College and married Georgiana Whitmore.

1815 - He left Cambridge settled in London. He wrote a paper on functional equations.

1816 - He was elected a Fellow of the Royal Society of London.

1819 - Began to plan the **Difference Engine** .

1820 - He became a member of the Royal Society of Edinburgh and helped to establish the Royal Astronomical Society.

1822 - On June 14th, he officially mentioned about his project and his findings in a research paper.

¹¹ "Charles Babbage," <http://top-biography.com/9090-Charles%20Babbage/>

- 1823** - He began to seriously construct and develop a prototype of **Difference Engine**, which is able to calculate logarithms and trigonometric functions. He used all the plans that he previously created. On July 13, he received a gold medal from the Astronomical Society for the success of his project.
- 1827** - (In August) He lost his wife, who was 35 years old. He also lost two of his children. He traveled on the Continent.
- 1828** - He returned back and became Lucasian Professor of Mathematics at the University of Cambridge.
- 1830** - He wanted to move his workshop to his house and built a fireproof workshop. During this year, he also created the first accurate actuarial tables that were used in insurance calculations.
- 1832** - He finished to write “Economy of Manufacturers and Machinery”.
- 1834** - He finally finished to design his new calculator, which is called **Analytical Engine**.
- 1840** - He had financial problems and went to Turin. He met and discussed his plan and projects with Menabrea.
- 1851** - He had to stop working on the Analytical Engine because of financial problems.
- 1871** - He passed away in London, England on October 18, 1871.

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