

## Chapter 1

# Computer Systems – Past, Present & Future

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### 1. Introduction

Historically, there has been a wide variation in the improvements introduced by new devices for helping humans perform basic tasks. For example, with walking speed as a basis of comparison, the approximate 200-fold increase in transportation speed brought about by airplanes is far more impressive than the five-fold increase created by bicycles. In these terms, computers outrival most other devices. For instance, consider the multiplication of two nine digit numbers. By hand, this takes about 10 minutes of time by an average person (try it!). Current, fast computers can perform such a multiplication in 100 nanoseconds ( $10^{-9}$  seconds). This implies a speed improvement of 10 orders of magnitude, an increase so large that it revolutionizes the applications in which calculations and, in a more general sense, data processing tasks, play an important role. The most astonishing fact is that this improvement in technology required a time span of only 40 years.

However, the past few decades have been no more than an acceleration of a development that began centuries ago. This chapter traces the history of computer systems from its origins to the current state of the art, and concludes with a perspective on future computer systems. Computer systems are regarded here as a composite of central processing units, storage devices, peripheral equipment, and basic system software. The relationships among these components are discussed as well as the factors that have influenced their design.

### 2. A bit of history

The modern computer was not a single invention. Rather it has resulted from the spread of ideas across the disciplinary boundaries of mathematics, physics, mechanical engineering, and electrical engineering. Below, some of the more important developments leading to the current state of computer technology are sketched. As will be seen, the implementation of well under-

stood principles of operation has occasionally had to wait many years for the required technological breakthroughs to materialize.

### *2.1. Prelude*

The only technology available before the 19th century was the mechanical one. The first calculating aids were the counting frame (abacus) and counting tables [Husky & Husky, 1976], dating as far back as 500 BC. The development of modern calculating machines only started in the 17th century. Two well-known scientists of that time were involved, Pascal and Leibnitz. Pascal developed a two-operations (addition and subtraction) machine in 1642 and Leibnitz a four-operations machine in 1671 that included multiplication and division. These machines were true mechanical calculators. The technology of these machines eventually led to the class of mechanical desk calculators, in use until a few decades ago, when they were replaced by electromechanical calculators and, from 1975 onwards, by all-electronic calculators (such as the common pocket calculator).

Early calculators could perform only a single operation at a time, but not a programmable sequence of operations. However, at that time machines also existed, made for completely different purposes than calculating, for which sequences of actions could be set up in advance. These sequences can be considered as a program, which controlled those machines automatically, i.e., without human intervention.

Two developments are worth mentioning, as they form the prelude of the stored program concept to be discussed later on. The first is that of mechanical musical instruments or automatophones. The first historically documented automatophone dates back to the 9th century in Baghdad, where three brothers constructed an automatophone whose 'brain' was a revolving cylinder with pegs [Sadie, 1984]. This technique of revolving cylinders was also applied in the 16th and 17th centuries to carillons placed in clock towers and to the first barrel organs in the 18th century. The second development is the use of punched cards in 18th century weaving machines that produced fabrics with complicated patterns. The punched cards defined the patterns and could be connected to each other to form a chain of varying patterns.

The Jacquard punched-card controlling mechanism inspired Charles Babbage in 1833 in the design of the Analytical Engine [Goldstine, 1972; Wilkes, 1956]. Although the Analytical Engine was never completed, its design is of importance because it introduced the concept of a stored program for controlling a calculating engine.

Another important development was the use of punched cards to store and automatically process the enormous amounts of data involved in the 1890 census in the USA. Herman Hollerith developed a system in which information such as age, sex, etc. could be stored on a punched card. After all the cards had been gathered, an automatic electromechanical machine was used to tabulate the appropriate data. This tabulating machine became a great success.