Computer Architecture

Lecture I

The history and the perspectives of evolution of computers

The earliest history of counting machines, *part I*

Definition: **Computer – a programmable counting machine**

- The first machines which allowed automation and speed-up
  of addition and substraction of relatively large numbers were ***abacuses***
  used in *Babylon Mesopotamia* (todays *Southern Iraq* city of *Bahhdad*).
  They were invented about 2700–2300 B.C. and used a simple version
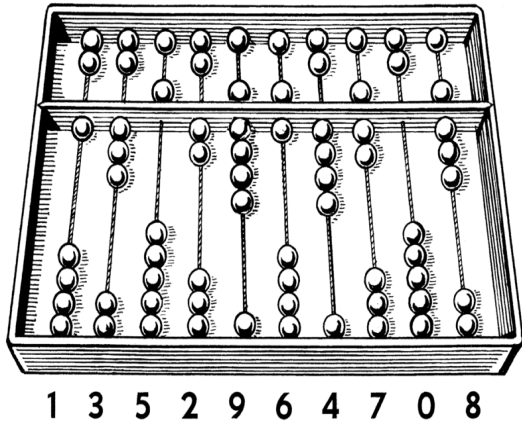 of what is now called a *positional numbering system* (Fig.2).

$$\left(a_n\, a_{n-1} \ldots a_1\, a_0 \right)_b = \sum_{k=0}^{n} a_k \cdot b^k$$

$$(11010)_2 = 0 \cdot 2^0 + 1 \cdot 2^1 + 0 \cdot 2^2 + 1 \cdot 2^3 + 1 \cdot 2^4 = 2 + 8 + 16 = (26)_{10}$$

$$(4325)_{10} = 5 \cdot 10^0 + 2 \cdot 10^1 + 3 \cdot 10^2 + 4 \cdot 10^3 = 5 + 20 + 300 + 4000 = (4325)_{10}$$

$$(4c2a)_{16} = 10 \cdot 16^0 + 2 \cdot 16^1 + 12 \cdot 16^2 + 4 \cdot 16^3 = 10 + 32 + 3072 + 16384 = (19498)_{10}$$

1 3 5 2 9 6 4 7 0 8

Fig. 1 Chinese abacus   **Fig. 2 Positional numbering system – binary, decimal, hexadecimal**

The earliest history of counting machines, *part II*

- Invention of *logarithm fuction* and it's properties in 1614 by Swiss
  mathematician *J. Burgi,* which inspired *B. Pascal* to construct in 1642
  a first mechanical counting machine which not only allowed quick addition
  and substraction but also could easily be used for multiplication,
  division, finding powers and roots. The machine used very well
  known (today) logarithm function most useful properties i.e:

$$log_{10}(a \cdot b) = log_{10}(a) + log_{10}(b) \text{ and } log_{10}(a/b) = log_{10}(a) - log_{10}(b)$$

which allowed making multiplication and division in terms of addition
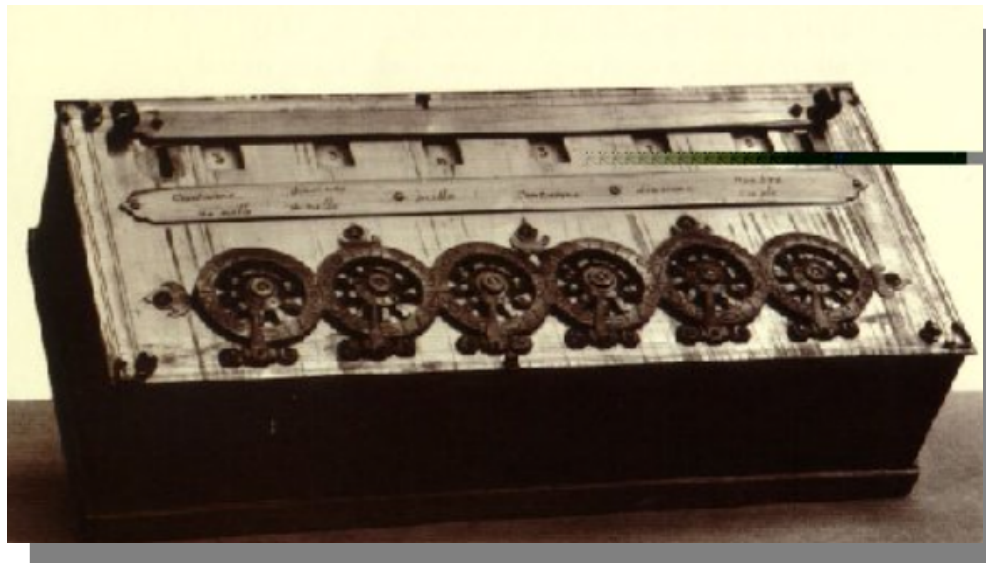and substruction. The Pascal's machine is depicted in Fig. 3.

Fig. 3 Pascal's counting machine

The earliest history of counting machines, *part III*

- The first programmable machine, however not the counting machine, was invented by French weaver *J. Jacquard* in 1810. Jacqurd's universal weaving machine used punched cards to code weaving patterns for textile fabrication.

Fig. 3a Jacquard's weaving machine

Fig. 3b Punched cards for weaving pattern fabrication instructions

The earliest history of
counting machines, *part IV*

- In 1822 *Charles Babbage* makes a *Difference Engine*, which goal is to quickly
  calculate consecutive values of arbitrary degree polynomials by a method of
  differences. Since polynomials are used (even in todays computers)
  to approximate any analyical functions, such as trigonometric, logarithm,
  and so on, the engine could be efficiently used to porduce tables of
  mathematical functions. It was programmed by initial setting of the machine
  and produced consecutive results in so called iterations, achieved by a steering
  handle rotation. In 1840 Babbage revised a project of his difference engine and
  added a possibility of programming the machine by punched cards
  storing a simple operational instructions for underlying difference engine.
  The new machine got the name *Analytical Engine* and is now considered to be
  a first modern computer.

The earliest history of counting machines, *part V*
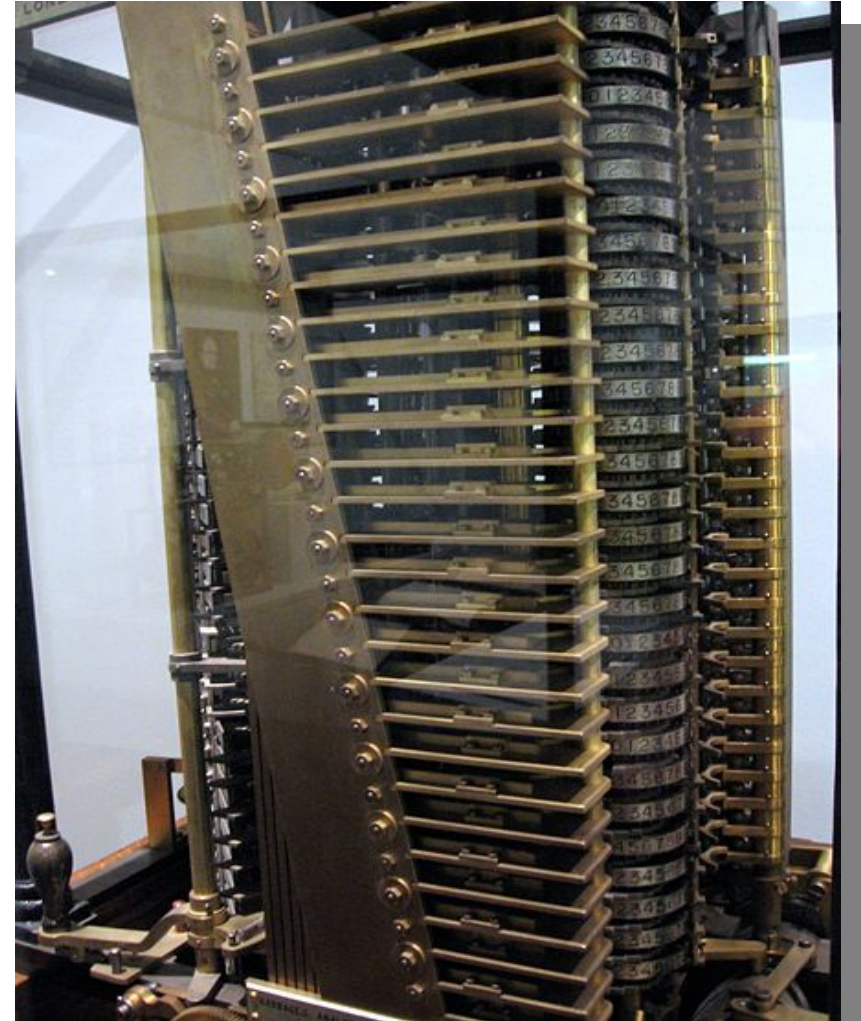

Fig. 4a Babbage's difference engine

Fig. 4b Babbage's analytical engine

The history of modern computers *part I*

- In 1847 and 1854 English mathematician *George Bool* along with his
   French collegue *Augustus de Mrogan* invent a mathematical formalism
   for logic description using binary notation **0 – False**, **1 - True**.
   At first the work is hardly considered useful, but today this system
   is used to represent numerical data and basic logical and
   arithmetical operations in every modern computer!

- Finally 1937 English mathematician *Alan Turing*
   using the concepts of Bool and de Mrogan
   mathematically formalises so called **Turing Machine**
   which is a theoretical model of a modern computer.
   He also proves that his machine is able to solve any
   computational problem that can be stated in terms of
   deterministic algorithm. Turing is often called
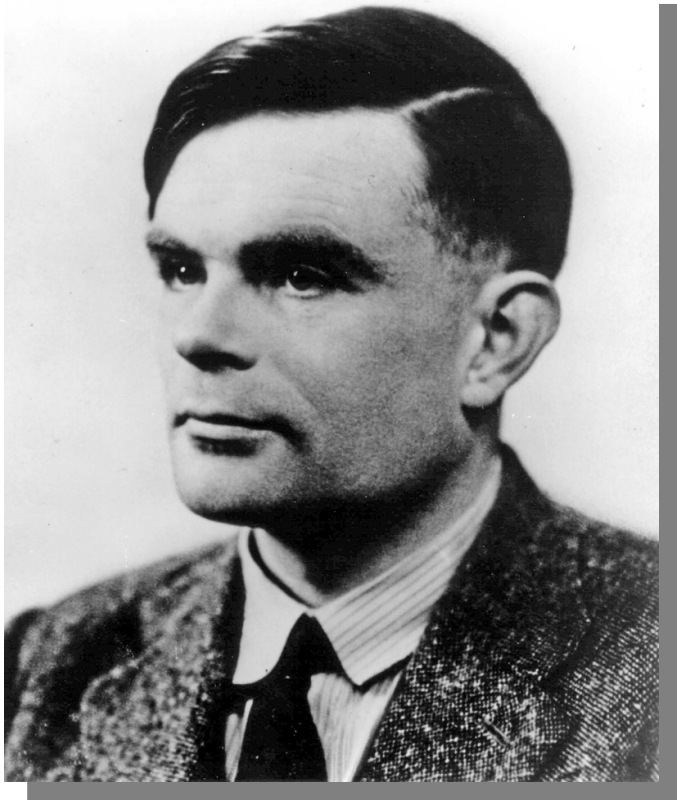   **a father of modern computer science / informatics.**

Fig. 5 Alan turing

The history of modern computers *part II*

- In 1884 American engineer Thomas Edison discovers so called Edison Effect and creates a vacuum tube, which is an electrical amplifier which can operate as a very fast on/off swich. This date is considered as a birthdate of modern electronics. - Using Edison's vacuum tubes during the Second World War American engineeres build a computer called ENIAC (Electronic Numerical Integrator And Computer), to perform ballistc calculations. ENIAC the world's first electronic computer.

It's parameters were:
- used punched cards as a data/program storage media
- 18800 vacuum tubes used as operational elements
- weight: 30 tons
- power consumption 140 kW (a small electric power plant)
- speed: 5000 fixed-point arithmetic additions (0,005 MIPS)

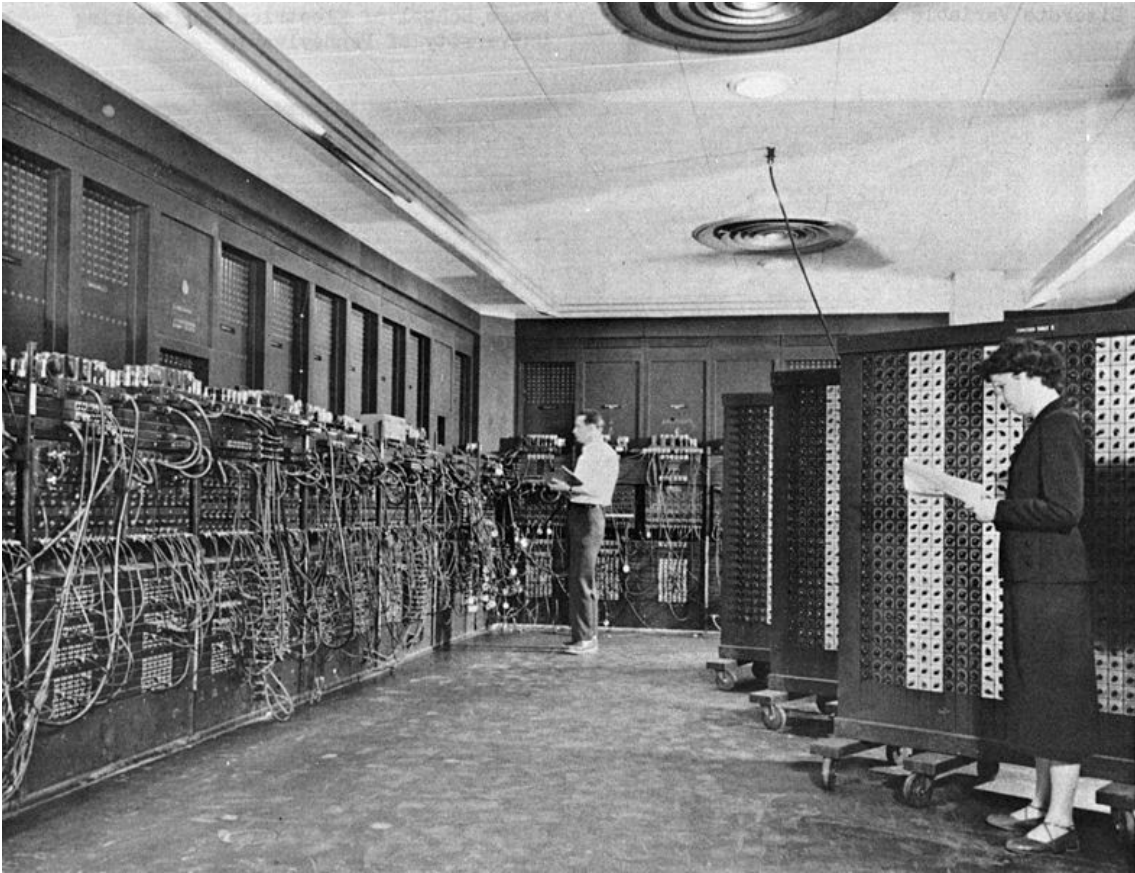# The history of modern computers *part II*

Fig. 6 ENIAC, the world's first electronic computer

Fig. 7 Edison's vacuum tube

The history of modern computers *part III*

- 1951 a breakthrough invention of the *transistor* made by American engineer *William B. Shockley* at Bell Laboratories. Transistor may be considered a very fast, small, low-energy consuming and a lot more reliable counterpart of a vacuum tube.
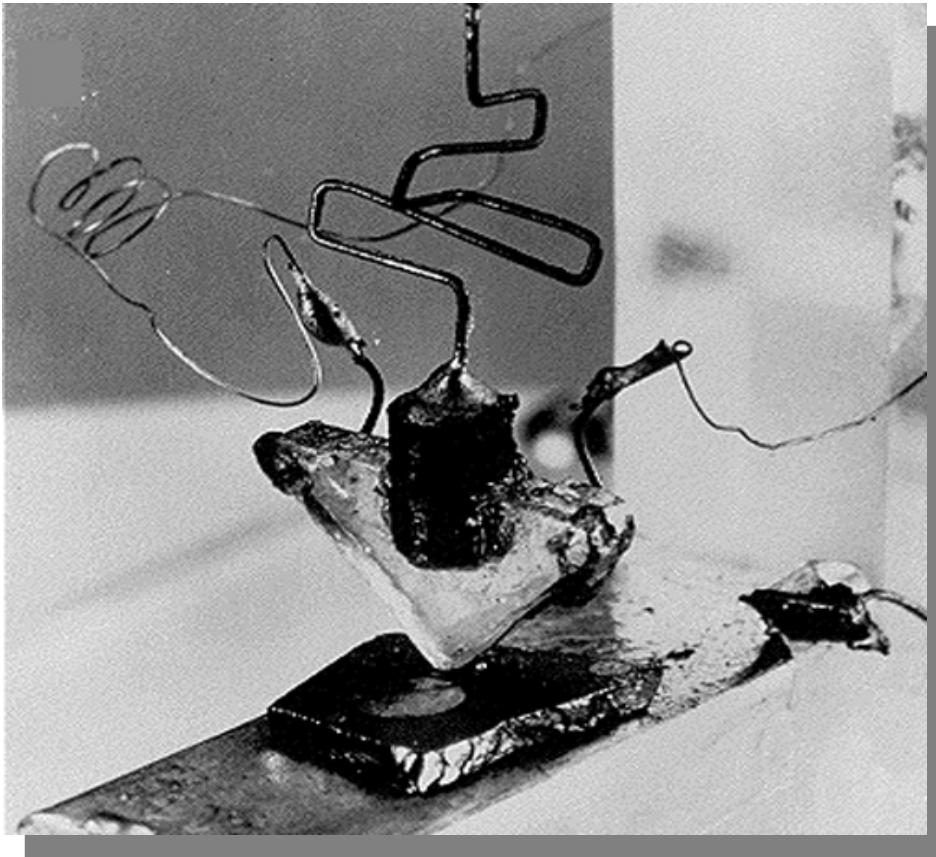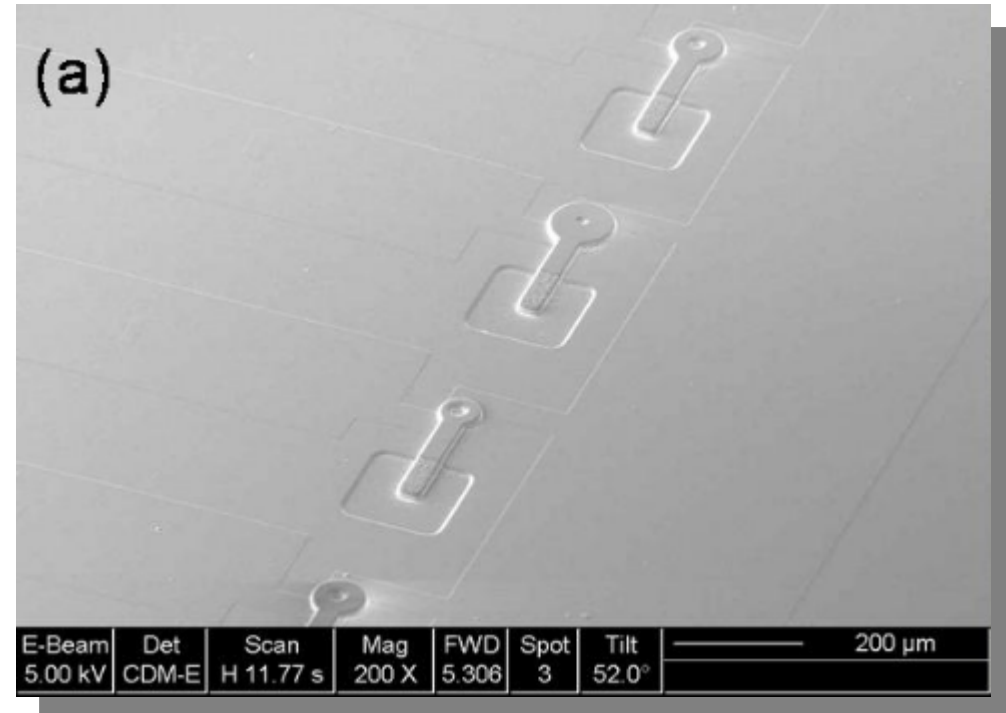

Fig. 7a The world's first transistor

Fig. 7b Microtransistors (magnified view)

The history of modern computers *part IV*

-1958 an *Integrated Circuit* (IC) invented in and constructed by *Jack Kilby* of Texas Instruments - a miniaturized electronic circuit consiting of semiconductor devices such as transistors as well as passive elements (resistors, capacitors), which is able to perform complicated arithmetical and logical functiuons.
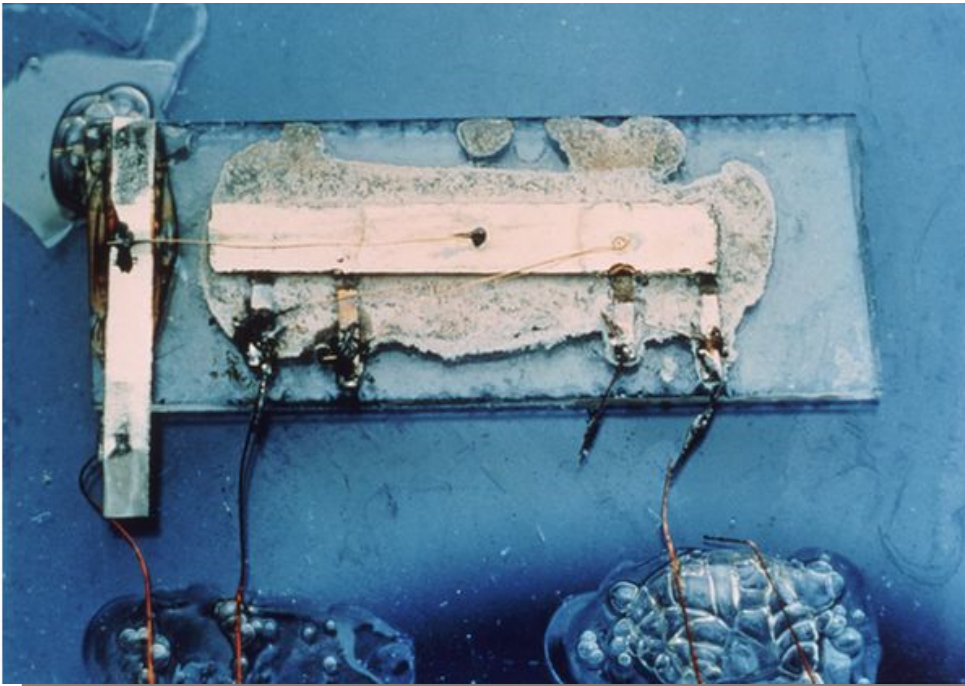Jack Kilby won a 2000 Nobel Price for his invention of an Integrated Circuit.
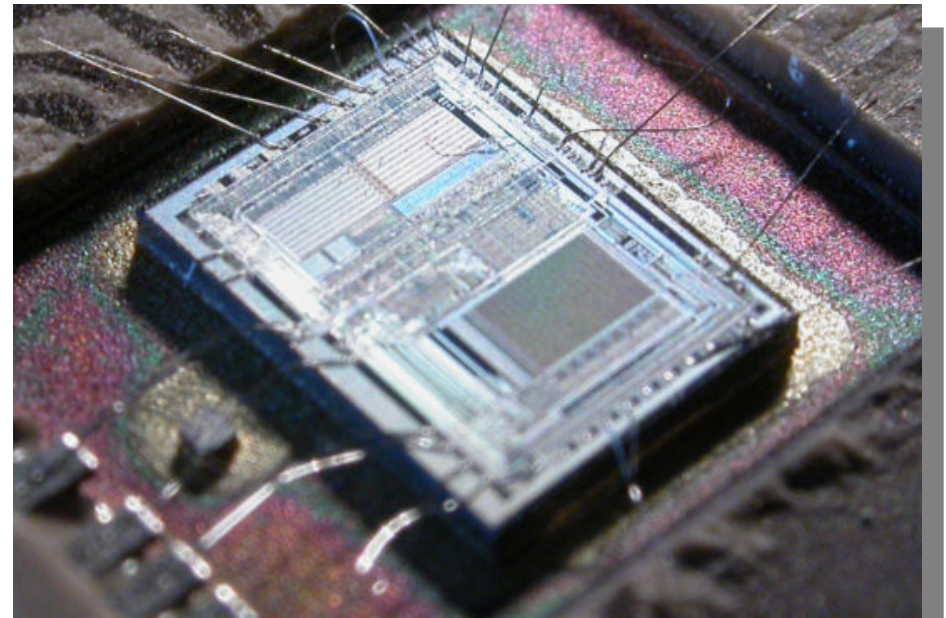

Fig. 8a Kilby's original IC

Fig. 8b Modern microscopic IC

The history of modern computers *part V*

- 1971 the first microprcessor Intel 4004 - 4-bit central processing unit (CPU) developed and released is a released by Intel Corporation. Fully fucntional central processing unit on a single chip.
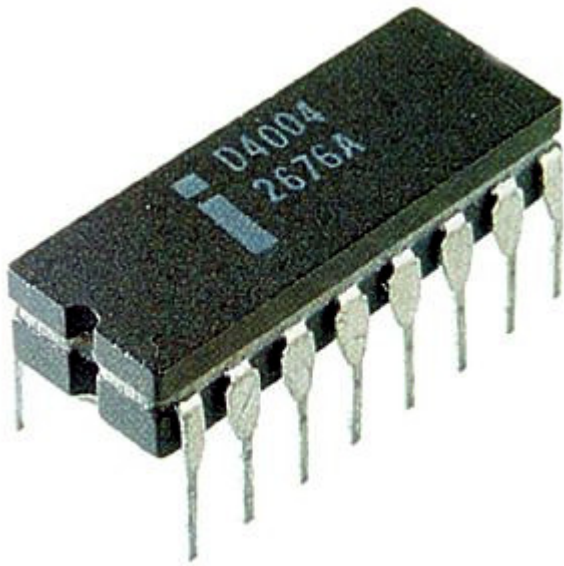

Fig. 9a The first Intel 4004 CPU

Fig. 9b Modern Intel Pentium CPU

The history of modern computers *part VI*

- 1975 the first microcontroller Intel 8048 - a fully functional computer embedded in a single chip. It had a bnuilt-in CPU, RAM and EPROM memories, external I/O and interrupt pins as well as reset and timing pin.
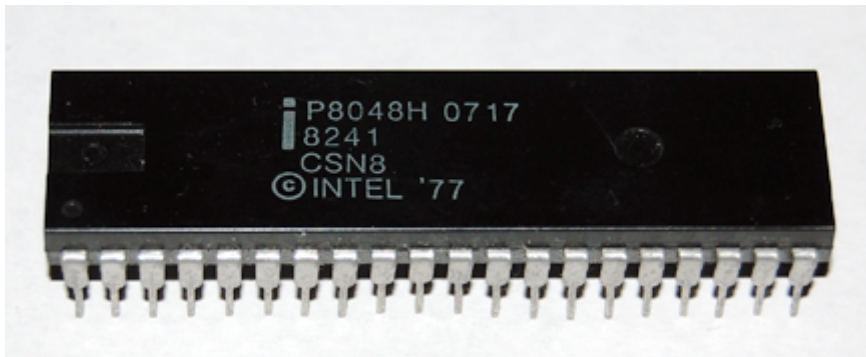

Fig. 10a The first Intel 8048 microcontroller

Fig. 10b Michrochip PIC microcontroller

The history of home/personal computers *part I*

- 1976 the first home computer designed and mounted in a garage by two American Engineers *Steve Wozniak* (Polish roots) and *Steve Jobbs.*
  A year later they founded Apple Computer Company which prospers well till today.

Fig. 11a The world's first home computer

Fig. 10b Wozniak and Jobbs with Apple I

The history of home/personal computers *part II*

- 1982 *Clive Sinclair* developes a first popular home computer ZX-Spectrum 81. For his project he is later rewarded a knighthood for "services to British industry" (from now on his official name is Lord Clive Sinclair).

Fig. 12 Sinclair's ZX-Spectrum 81

The history of home/personal computers *part III*

- 1978 foundation of *Atrari Inc*, realease of the world's first console
  and videogame *Pong* – begining of the electronic game industry.
- 1984 release of the most popular home computers family (also in Poland)
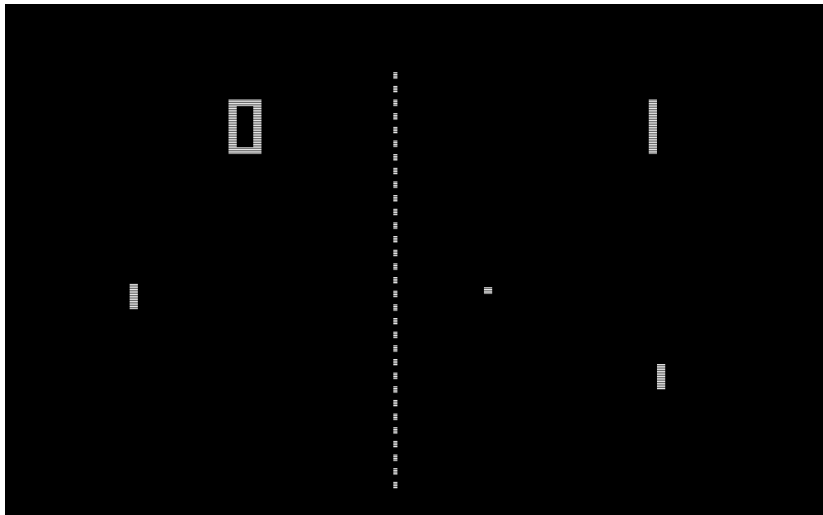 Atari XL/XE series.

Fig. 13a Atari 2600 game console with Pong

Fig. 13b Atari 130 XE

The history of home/personal computers *part IV*

- 1981 first IBM PC computer was released. IBM published it's all technical documentation what seemed a suicidal step at that time. It appeared to be a great strategy, because hardware developers soon started to legally copy original design making this model the most popular computer of all times.

- 1981 Bill Gates founds Microsoft Corporation and adjusts original ZX-Spectrum CP-M operating system to IBM PC machines, he calls it MS-DOS and signs a contract with IBM to distribute this system with IBM PC computers. The next step is Windows 1.0 (an idea of graphical user interface invented by Apple). At the beginning Windows is just a graphical interface for MS-DOS, in the mid 90's it becomes self-suffitient graphical operating system for PCs.

Fig. 14a First IBM PC

Fig. 14b Bill Gates as a young student

Thank you for today's lecture.