CSC-153
MICROPROCESSOR

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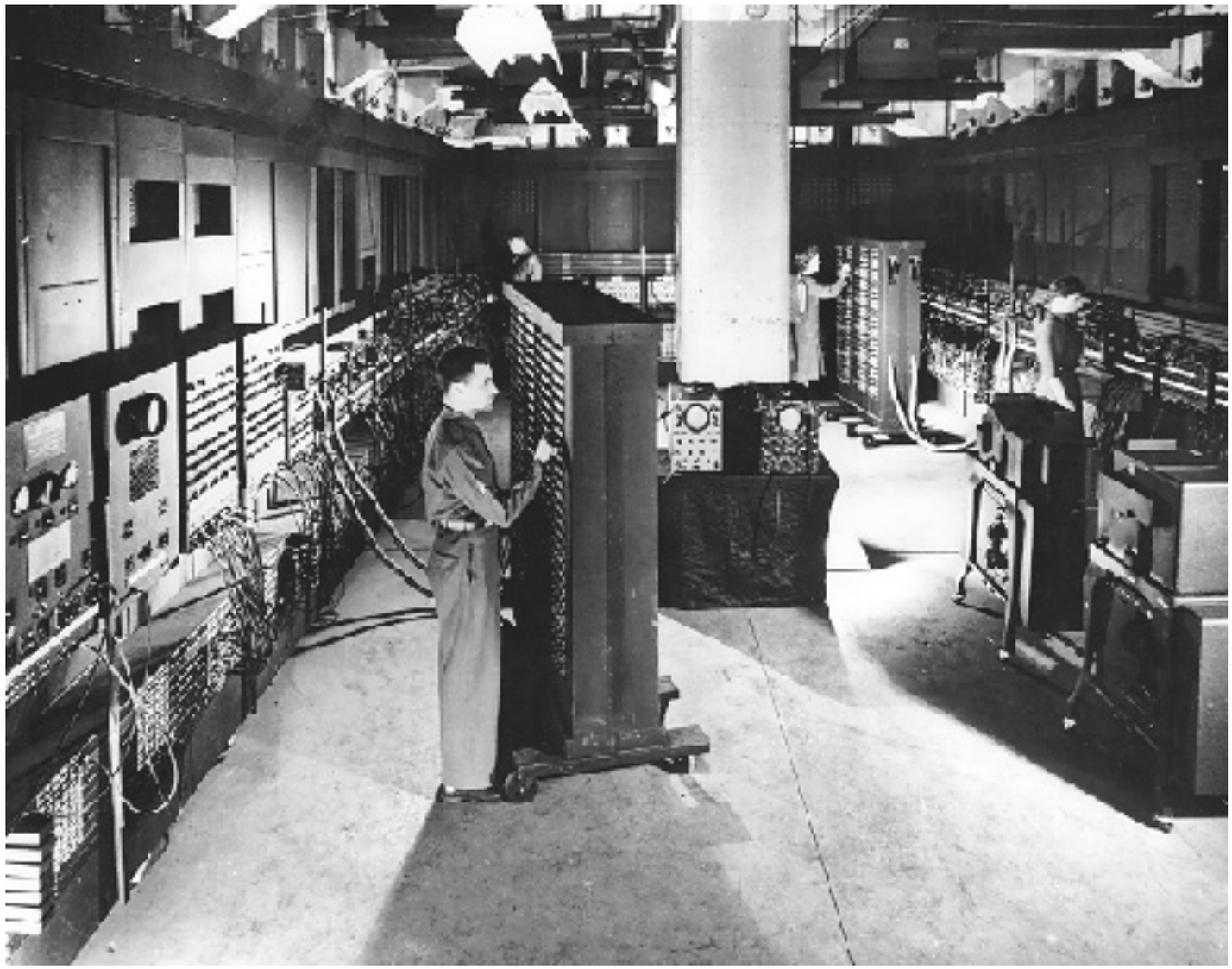
Background



ENIAC (Electronic Numerical Integrator and Calculator)

Background


Nokia 5210
EXFO FTB-100
Sanyo SSP-PD10
Nokia 7650
HP Photosmart 1315
Sony Ericsson T68
Audiovox Thera
Polaroid MP3 Camera
SOMA Networks SOMAPort
Seagate Cheetah
C-Pen
Nokia Set-top-box
Panasonic Toughbook
Good G100
Game Boy AdvanceSP
Kodak MP3 Camera
Samsung NEXiO S150
Sendo
Hanzoom-2000 MP3
ContiTeves ABS
DiskOnKey
Turtle Beach Audiotron
Nokia Music Player
Nokia 5510
InCard MoKard
Sharp Z-800
Automotive
Consumer
Imaging
Networking
Secure
Storage
Wireless

Background


Security Camera
Internet
Phone
Gaming System
Notebook PC
Smart Thermostat
Smart Meter
Tablet
Broadband
Gateway
HDTV
IPTV
Electric Car & Charging Station
Appliance
PC
Air Conditioner
DVR

Objective and evaluation criteria

- Course Synopsis: This course contains of fundamental concepts of computer organization, basic I/O interfaces and interrupt operations.

- The course objective is to introduce the operation, programming and application of microprocessor.

- Evaluation Criteria: **Total marks: 20**

- Assignments = 6
- Class Tests =8
- Presentation and participation=4
- Attendance= 2

Unit 1: Introduction

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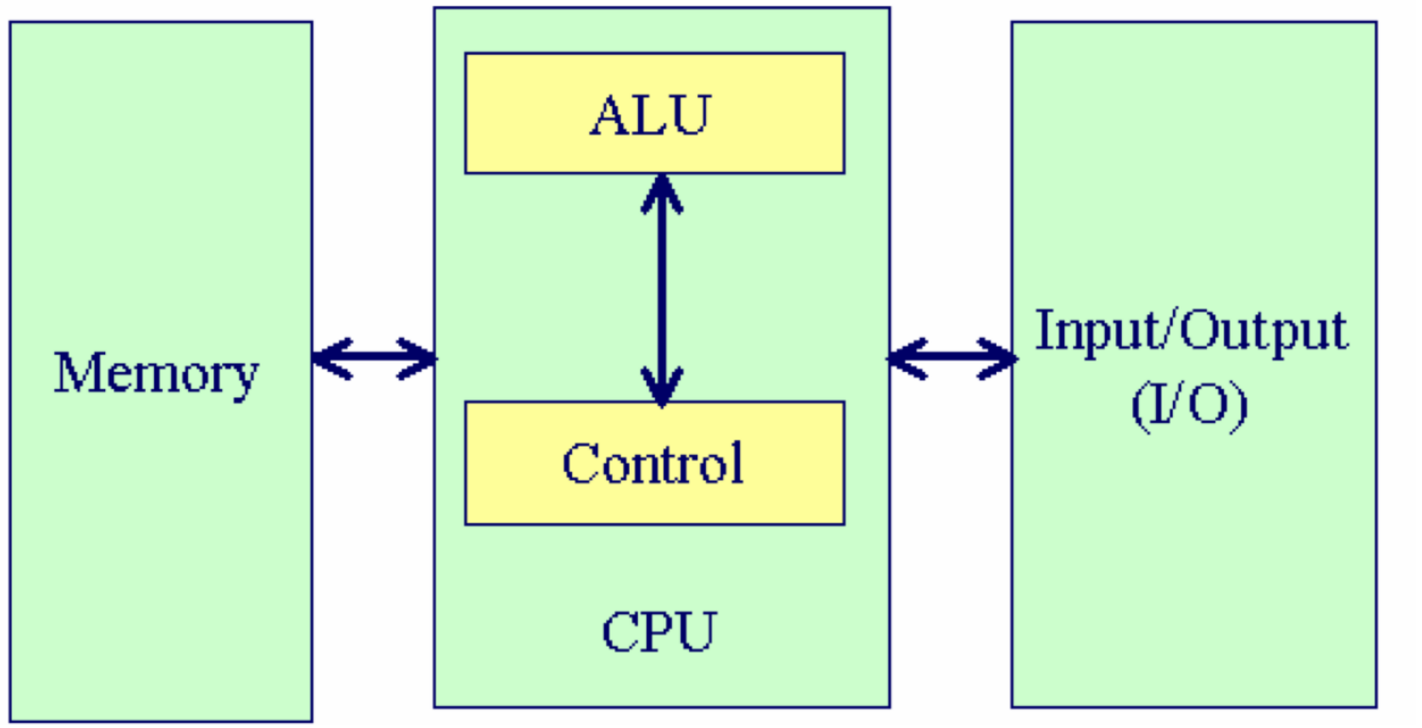
Concepts of Microprocessor



Differences between:

– Microcomputer – a computer with a microprocessor as its CPU. Includes memory, I/O etc.

– Microprocessor – silicon chip which includes ALU, register circuits & control circuits

– Microcontroller – silicon chip which includes microprocessor, memory & I/O in a single package.

What is a Microprocessors

- It is a computer processor on a single integrated chip (IC).
- It contains millions of transistors which work together to store and manipulate data.
- It is also known as the Central Processing Unit (CPU)
- It is the “brain” inside a Personal Computer”.

Inside a Microprocessor

- A microprocessor executes a collection of machine instructions (a program) that tells the computer what to do.
- Based on the instructions, a microprocessor does three basic things:
  - Performs arithmetic and logic operations
  - Move data from one location to another
  - Make decisions and jump to a new set of instruction based on those decisions.

Definition of the Microprocessor

- A microprocessor is a programmable device that takes in numbers, performs on them arithmetic or logical operations according to the program stored in memory and then produces other numbers as a result.

- A microprocessor is the chip containing some control and logic circuits that is capable of making arithmetic and logical decisions based on input data and produces the corresponding arithmetic or logical output.

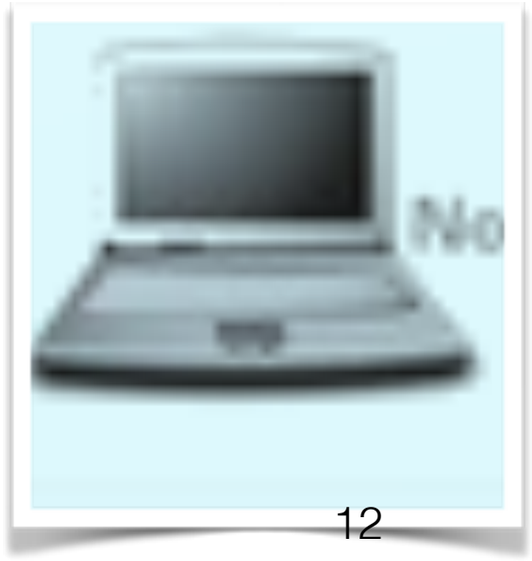
Definition of the Microprocessor

- **Programmable device:** The microprocessor can perform different sets of operations on the data it receives depending on the sequence of instructions supplied in the given program. By changing the program, the microprocessor manipulates the data in different ways.

- **Instructions:** Each microprocessor is designed to execute a specific group of operations. This group of operations is called an instruction set. This instruction set defines what the microprocessor can and cannot do.

Applications of Microprocessors

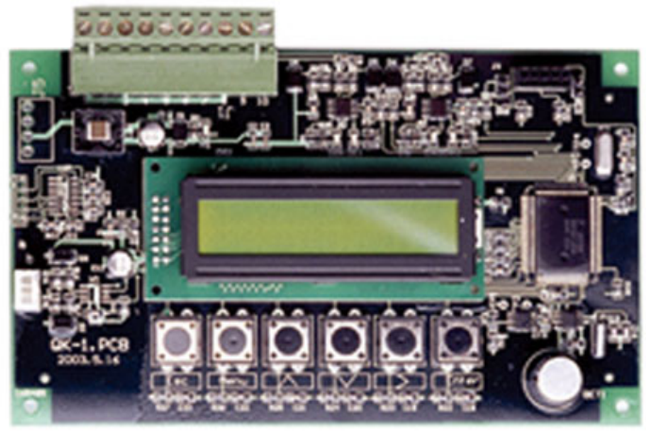
- Microcomputers
  - A microcomputer is built around a microprocessor. It includes a microprocessor, a memory unit, and input-output devices (keyboards, monitors, printers, etc.).



Applications of Microprocessors

- Control Systems.

–Microprocessors play an important role in many industrial control systems such as temperature controllers, pressure sensors, environment control systems, etc.



Applications of Microprocessors

- Embedded Systems.

–They are also incorporated into thousands of other devices used in daily life that include

  – large and small household appliances,
  – cars (and their accessory equipment units) and car keys,battery charges,
  – light switches/dimmers and electrical circuit breakers, smoke alarms,
  – hi-fi audio/visual components (DVD video system and HDTV broadcast systems),
  – Medical equipments,measuring and testing equipments,
  – security systems (fingerprint, voice or retina) e.t.c.

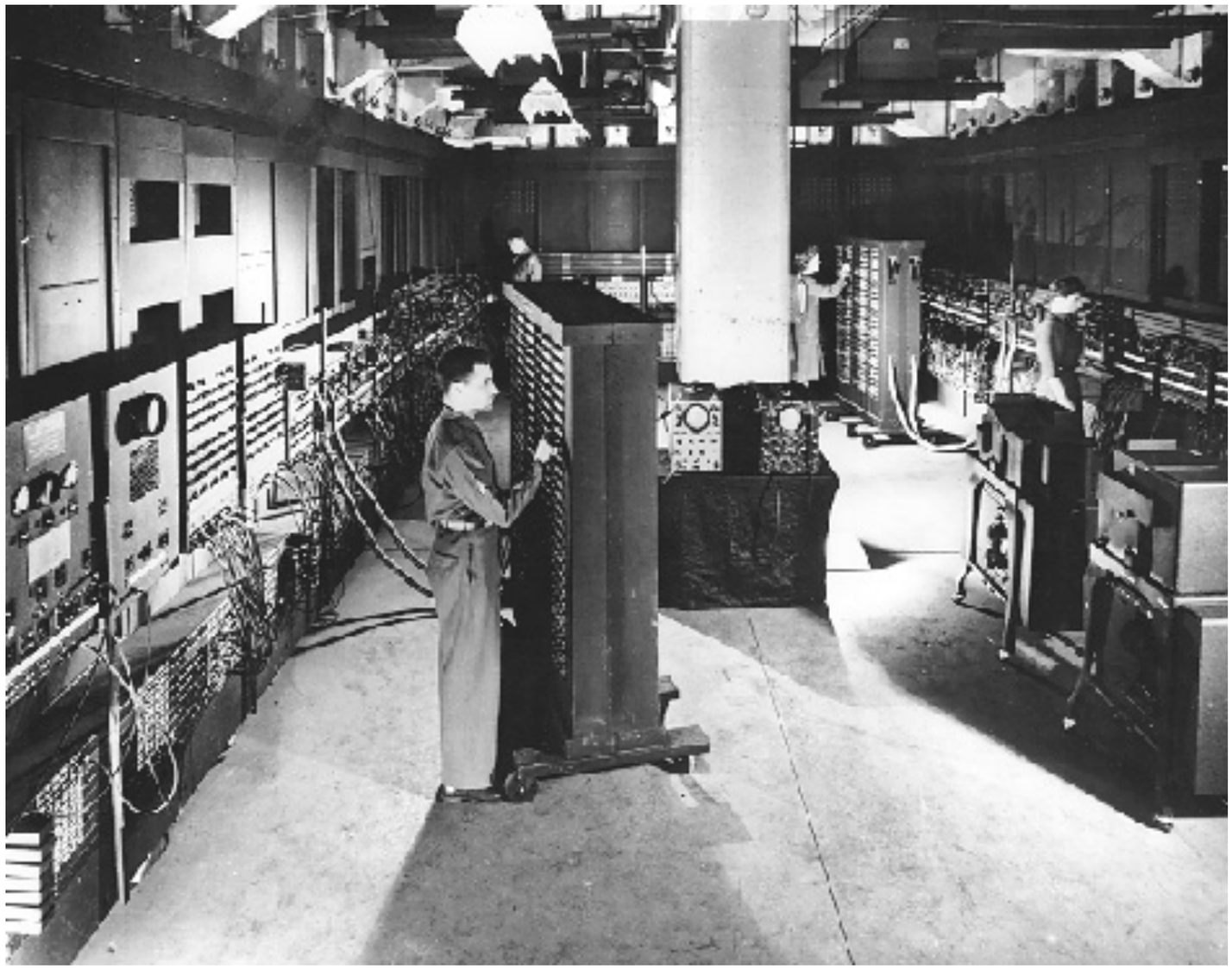
- Microprocessors used in consumer devices are powerful as well as low-cost.
- A microprocessor control program (embedded software) can be easily tailored to different needs of a product line, allowing upgrades in performance with minimal redesign of the product.

Historical background

- In 1642, Blaise Pascal developed mechanical calculator to assist his father.
- Leibniz improved it to perform multiplication.
- In 1823, Charles Babbage made difference engine.
- In 1830, difference engine was improved and named as analytical engine. It had

- Store(memory)
- The mill (computation unit)
- The input section (consists of punched cards)
- The ouput section (consists of punched cards)

ENIAC (Electronic Numerical Integrator and Calculator)



- First general purpose computer developed by John Mauchley and J. Presper Eckert at the university of Pennsylvania.

- Features

- 18000 vaccum tubes

- 30 ton weight

- 140 KW power

- They also proposed and designed EDVAC (Electronic Discrete Variable Automatic Computer)

The Von Neuman Machine

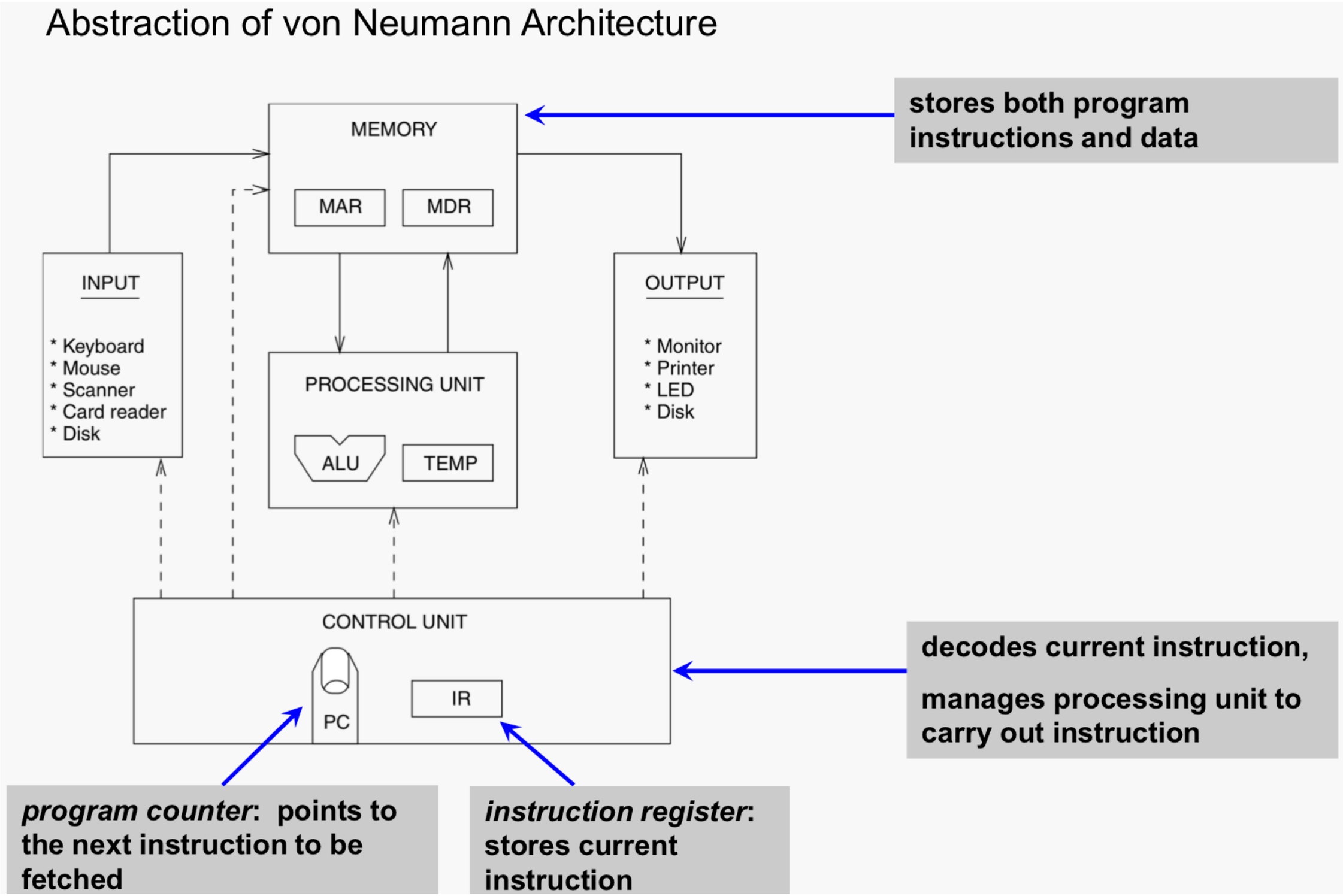
- 1945: John von Neumann wrote draft on EDVAC.
- The basic structure proposed in the draft became known as the “von Neumann machine”.
- The main idea was about "Stored program concept".

– a memory, containing instructions and data

– a processing unit, for performing arithmetic and logical operations

– a control unit, for interpreting instructions

The Von Neuman Machine



The Von Neuman Machine

It consists of 1000 storage locations, which can hold words of 40 binary digits.
Both data and instructions are stored in it in binary form.
It consists of

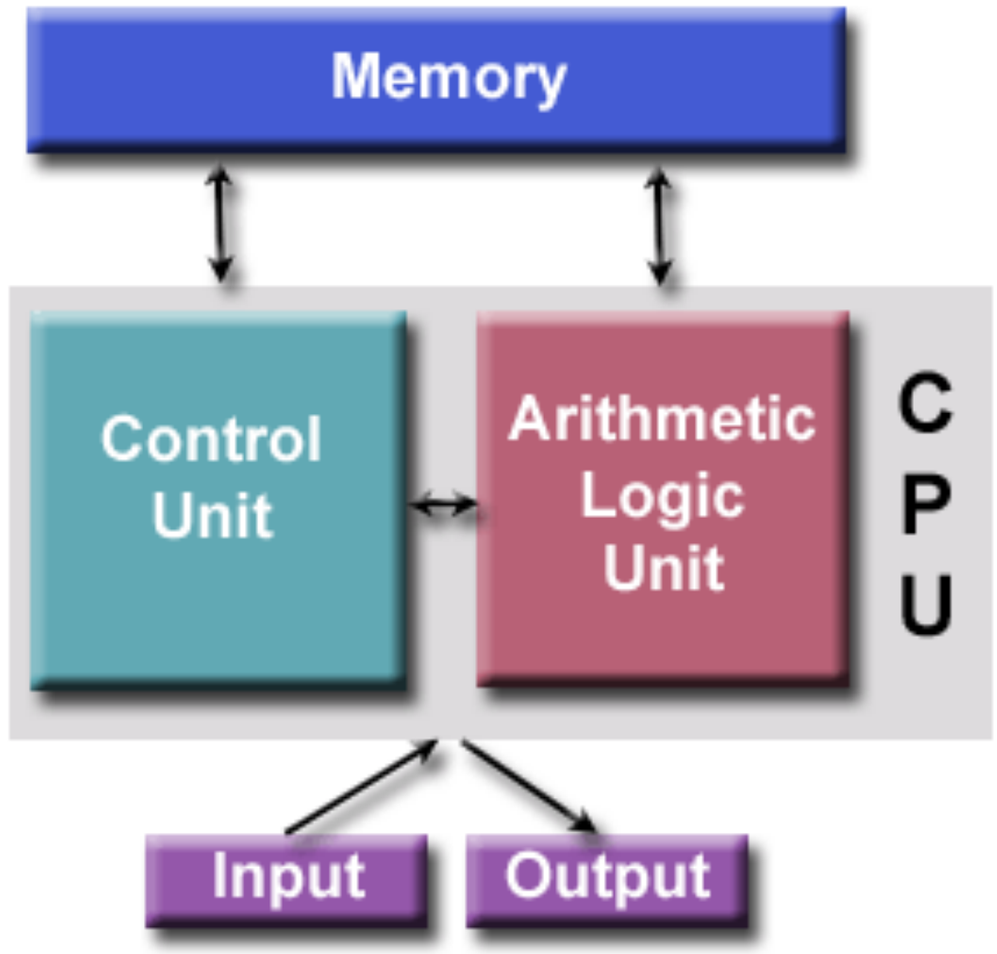
Memory address register (MAR)
- holds the address in memory of a word to be read from or written to.

Memory data register (MDR)
- a two-way register that holds word fetched from memory or word waiting to be stored in memory. Often, the MDR is expressed as the MBR (Memory Buffer Register).

Program counter (PC)
- the memory address of the instruction that is to be executed next.

Instruction register (IR)
- the instruction that has just been fetched from memory.

Temporary registers
- to hold operands and results of ALU operation.



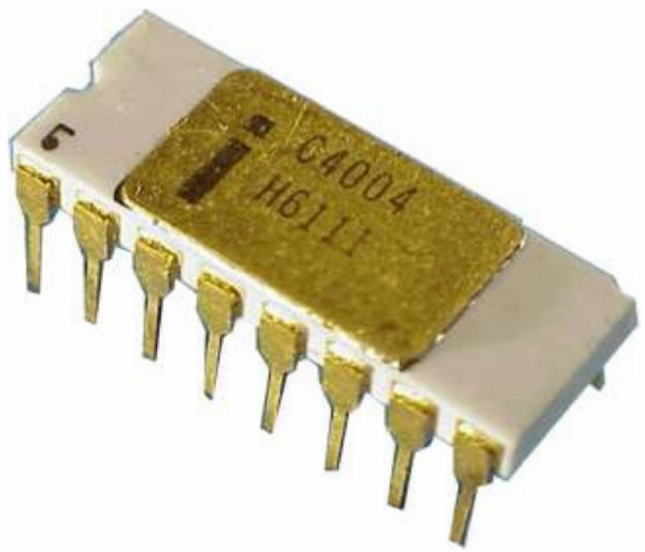
Simplified block diagram

Evolution of Microprocessor

- The advent of Integrated chip (IC) by Fairchild Semiconductors in 1959 triggered the development of microprocessor in single chip
- Commercially available microprocessors
  - 4-Bit Microprocessors
  - 8-Bit Microprocessors
  - 16-Bit Microprocessors
  - 32-Bit Microprocessors
  - 64-Bit Microprocessors

Evolution of Intel's Microprocessor

INTEL 4004



- Introduced in 1971.
- It was the first microprocessor by Intel.
- It was a 4-bit µP.
- Its clock speed was 740KHz.
- It had 2,300 transistors.
- It could execute around 60,000 instructions per second.

Used in first calculator

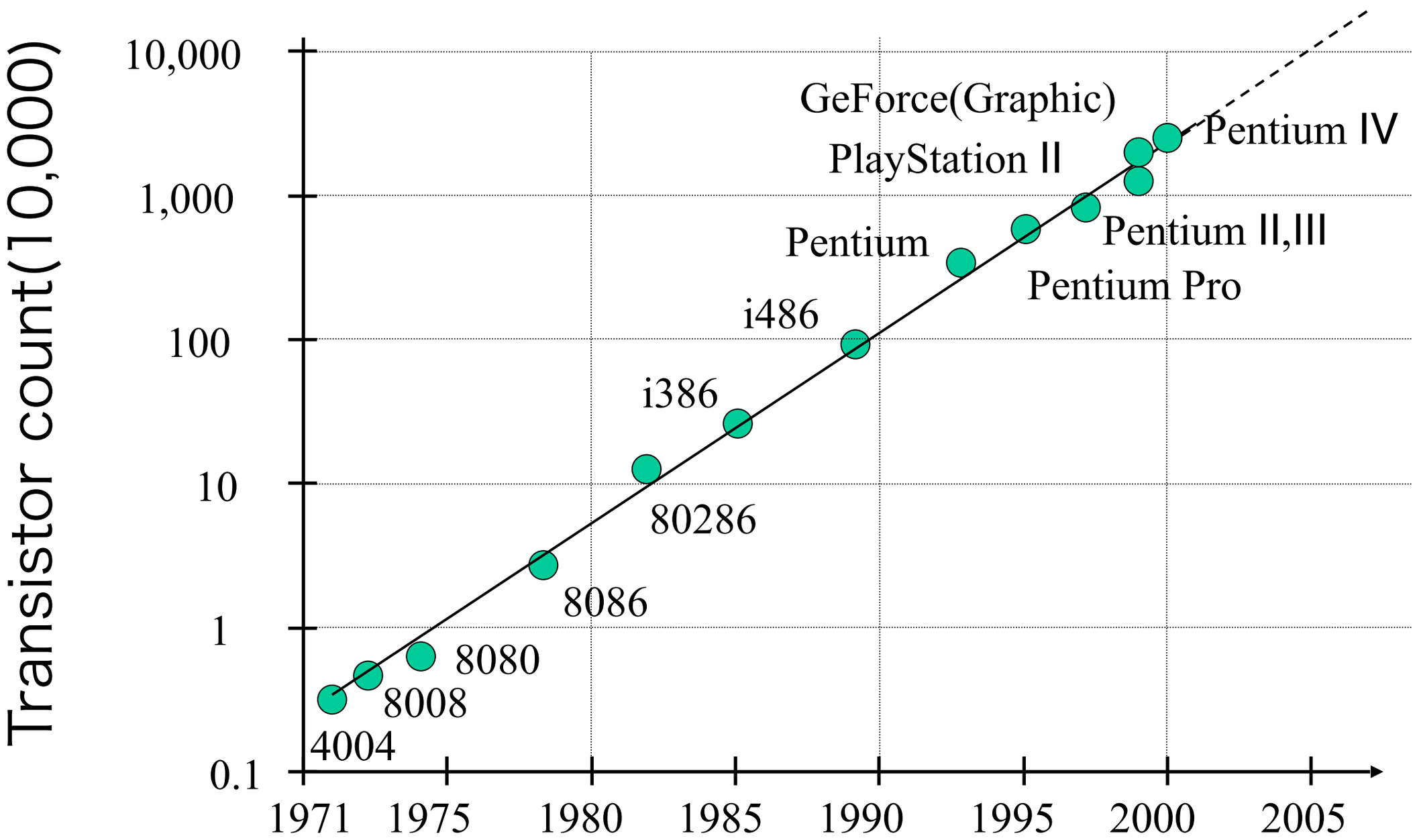
Evolution of Intel's Microprocessor

Name	*Date*	*Transistors used*	*Microns*	*Max clock speed*	*Address lines*	*Data width*	*MIPS*	*Max addressable memory*
8080	1974	6 K	6	2 MHz	16-bit	8-bit	0.64	64KB, no cache
8085	197	6.3K	3	MHz	16-bit	8-bit	0.64	64KB, no cache
8086	1978	29 K	3	8 MHz	20-bit	16-bit	0.80	1MB, no cache
8088	1979	29 K	3	5 MHz	20-bit	8-bit bus/ 16-bit	0.33	1MB, no cache
80286	1982	134 K	1.5	12.5 MHz	24-bit	16-bit	2.7	16MB, no cache
80386	1985	275 K	1.5	20 MHz	32-bit	32 bit	6	4GB, no cache
80486	1989	1.2 M	1	25 MHz	32-bit	32 bit	20	4GB, 8K level 1
Pentium	1993	3.1M	0.8	100 MHz	32-bit	64-bit/32-bit	100	4GB, 16K level 1
Pentium Pro	1995	5.5M	0.8	440 MHz	36-bit	64-bit/32-bit	440	64GB, 16K level 1 256K/512 level 2
Pentium II	1997	7.5M	0.35	266 MHz	36-bit	64-bit/32-bit	446	64GB, 32K level 1 256K/512 level 2
Pentium III	1999	9.5M	0.25	500 MHz	32-bit	64-bit/32-bit	1000	4GB, 32K level 1 256K/512 level 2
Pentium 4	2000	42M	0.18	1.5 GHz	32-bit	64-bit/32-bit	1,700	4GB, 32K level 1 256K/512 level 2
Pentium 4 Prescott	2004	125M	0.09	3.6 GHz	32-bit	64-bit/32-bit	7,000	64GB, 32K level 1 256K/512 level 2

Evolution of Intel's Microprocessor

Name	*Date*	*Transistors*	*MHz*
8086	1978	29K	5-10
– First 16-bit processor. Basis for IBM PC & DOS			
– 1MB address space			
80386	1985	275K	16-33
– First 32 bit processor , referred to as IA32			
– Added “flat addressing”			
– Capable of running Unix			
– 32-bit Linux/gcc uses no instructions introduced in later models			
Pentium 4F	2004	125M	2800-3800
– First 64-bit processor, referred to as x86-64			
Core i7	2008	731M	2667-3333

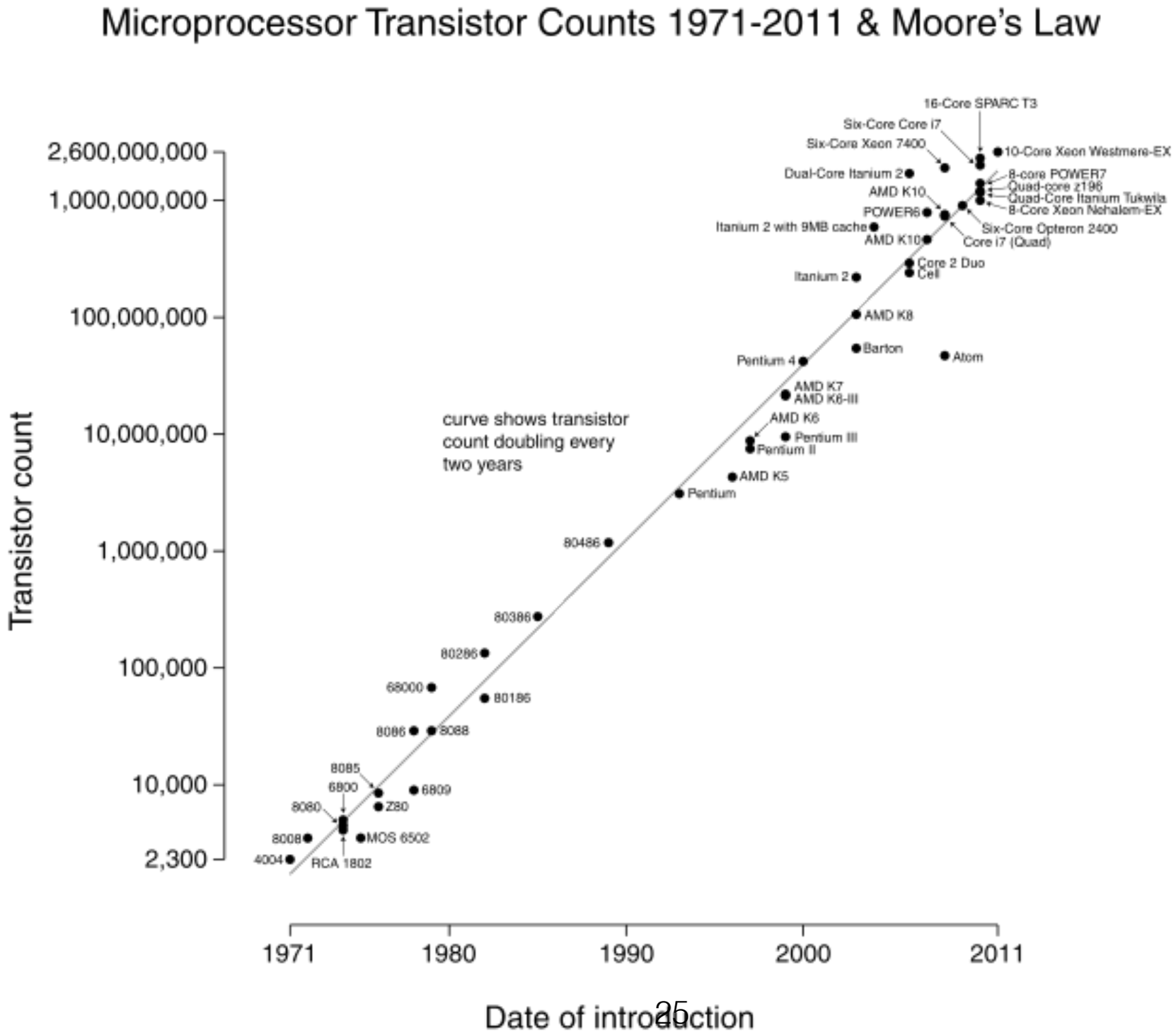
Evolution of Intel's Microprocessor



Moore'law ：No of transistor doubles every two year

(Gordan Moore 1965)

Evolution of Microprocessor



Evolution of microprocessor

Interesting Facts

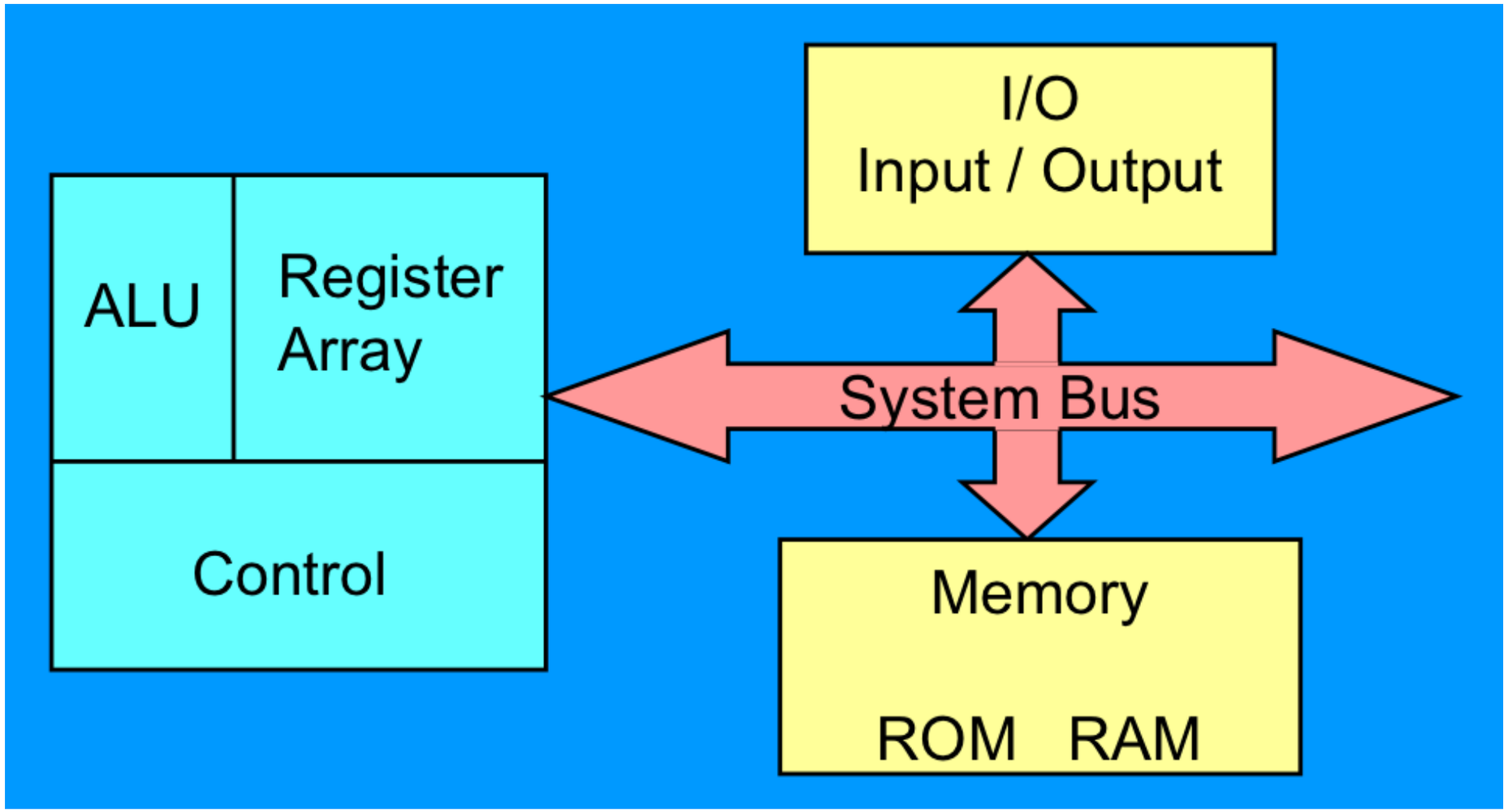
- 44 Billion dollars worth of Microprocessors were made in 2003 as well as sold. Most was spent on laptop and or desktop computers it takes about 0.2 % of the CPU's sold.

- Almost 56% of CPUs sold are 8 bit microcontrollers.

- Less the 10 % of CPUs sold are 32 bit or more. Most are sold in house hold appliances such as vacuums, TVs, Microwaves, toasters and so forth.

- About ten billion CPUs were manufactured in 2008. About 98% of new CPUs produced each year are embedded.

Organization of a microprocessor- based system



Organization of a microprocessor- based system

Microprocessor

Internally, the microprocessor is made up of 3 main units.

– **The Arithmetic/Logic Unit (ALU)**

•Area of microprocessor where various computing functions are performed on data. It performs addition, subtraction and logical operation such as AND, OR, XOR e.t.c

– **The Control Unit**

•Provides the necessary timing and control signals to all the operations in the microprocessor or microcomputer.

•Controls the flow of data between the microprocessor and memory or microprocessor and peripherals.

– **Register Array**

•An array of registers for holding data while it is being manipulated.

Organization of a microprocessor- based system

Memory

– stores information such as instructions and data in binary format (0 and 1). It provides this information to the microprocessor whenever it is needed.
Usually, there is a memory “sub-system” in a microprocessor-based system. This sub-system includes:
– The registers inside the microprocessor
– **Read Only Memory (ROM)** used to store information that doesn't change.
– **Random Access Memory (RAM) (also known as Read/Write Memory)** used to store information supplied by the user. Such as programs and data.

Input/Ouput

– It helps microprocessor to communicate with outside world. These are also knows as peripherals.

Organization of a microprocessor- based system

SystemBus

–wires connecting memory &I/O to microprocessor.

– **Address Bus**

- Unidirectional
- Identifying peripheral or memory location

– **Data Bus**

- Bidirectional
- Transferring data

– **Control Bus**

•Synchronization signals

- Timing signals
- Control signal

Harvard architecture

The Harvard architecture consists of separate memory location for the programs and data. Each memory space has its own address and data buses. As a result of this both instruction and data can be fetched from memory concurrently. Thus a significant processing speed improvement is observed over Von-Neumann type architecture. The Harvard architecture is shown below:

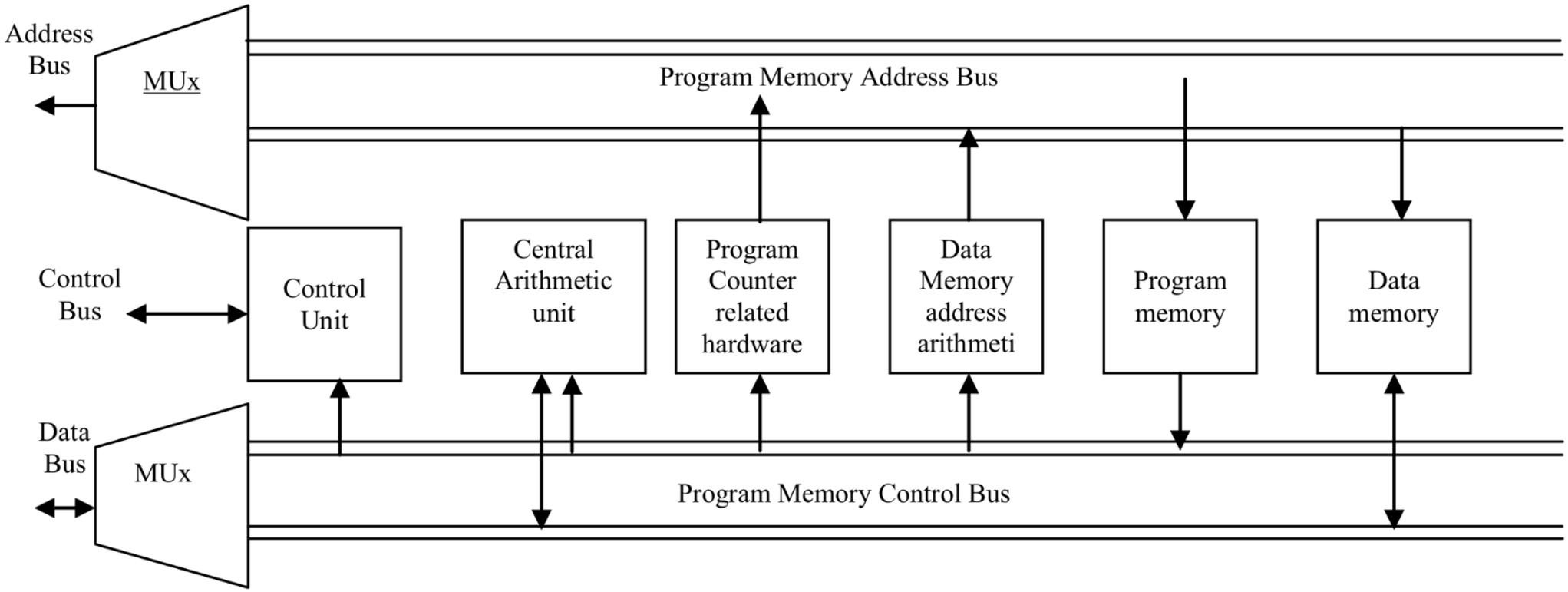


Fig: Block diagram of a Harvard architecture based microprocessor

- Expensive,faster not used in PC rather used in DSP

Harvard architecture

From the figure, we see there are two data and two addresses buses, for the program and data memory spaces separately. The program memory data bus and data memory data bus are multiplexed to form single data bus where as program memory address bus and data memory address bus are multiplexed to form a single address bus. Hence there are two blocks of RAM chips, one for program memory and other for data memory space. The data memory address arithmetic unit generates data memory addresses. The data memory address bus carries the memory address of the data where as the program memory address bus carries the memory address of the instruction. There is a central arithmetic logic unit (ALU), which consists of the ALU, the multiplier, accumulator, and scaling chief register. The program counter is used to address program memory. The PC contents are updated following each instruction decode operation. The control unit controls the sequence of operations to be executed. The data and control bus are bi directional where as address bus is unidirectional.

Harvard architecture vs Von Neuman

- Small space for data and instructions in Von Neuman while different space for data and instructions Harvard
- Separate address and data bus for program and data for Harvard.
- Operation speed is also enhanced in Harvard.