INTRODUCTION OF MICROPROCESSOR

DIAGRAM OF A COMPUTER SYSTEM

A **computer** is a programmable machine that receives input, stores and manipulates data//information, and provides output in a useful format.

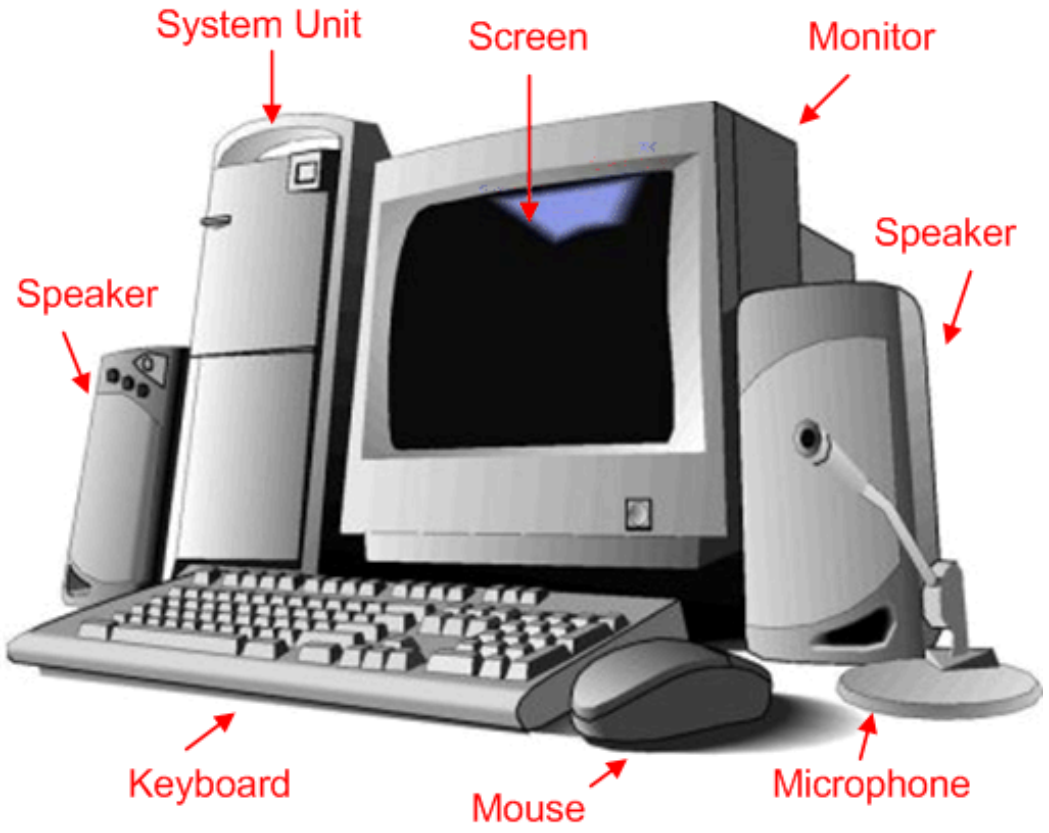
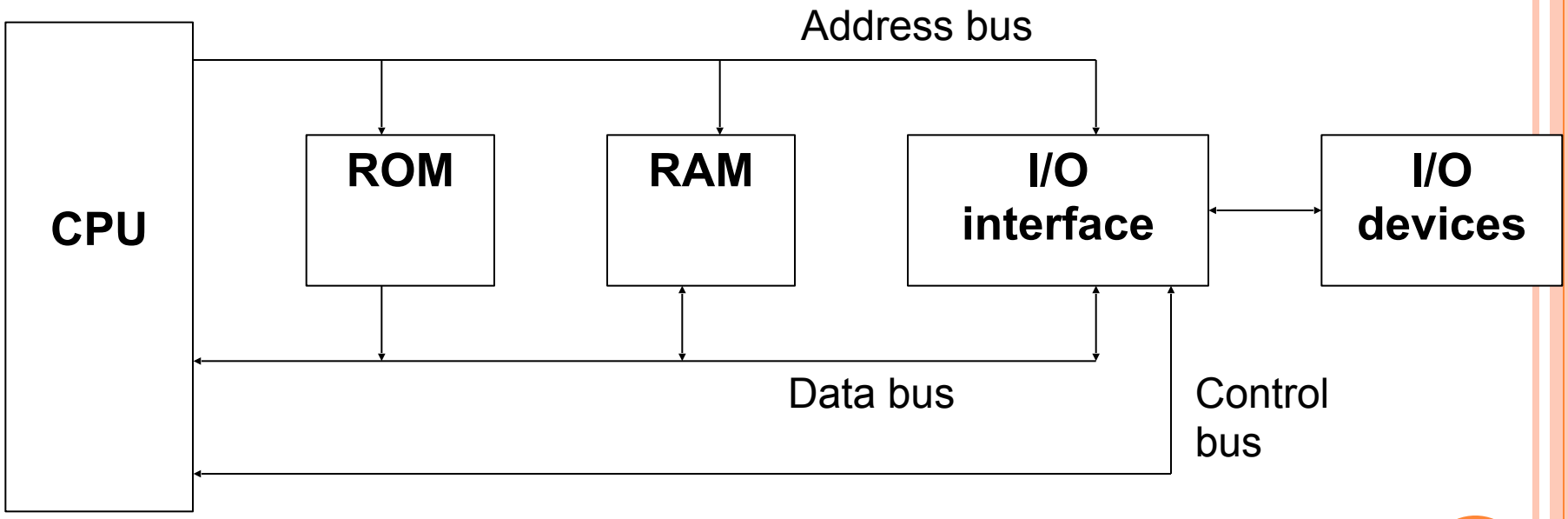


Diagram Of A Computer System

BLOCK DIAGRAM OF A BASIC COMPUTER SYSTEM

Basic computer system consist of a Central processing unit (CPU), memory (RAM and ROM), input/output (I/O) unit.



Block diagram of a basic computer system

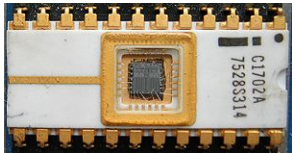
BASIC COMPONENT OF MICROCOMPUTER

1. CPU - Central Processing Unit
   - the portion of a computer system that carries out the instructions of a computer program
   - the primary element carrying out the computer's functions. It is the unit that reads and executes program instructions.
   - The data in the instruction tells the processor what to do.

Pentium D dual core processors

2. Memory

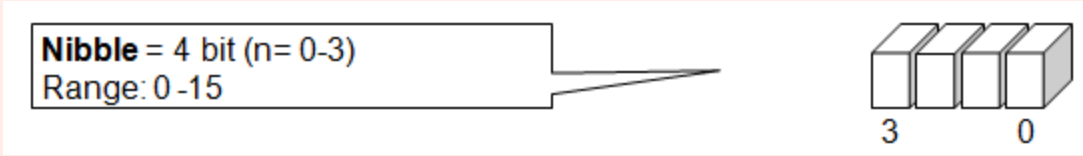
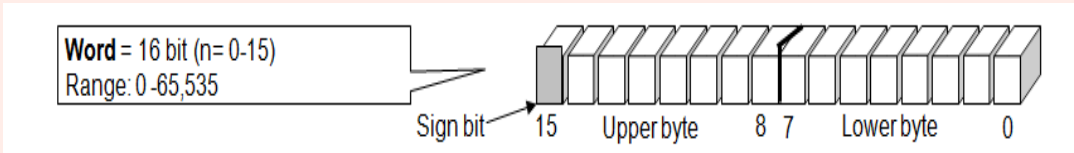
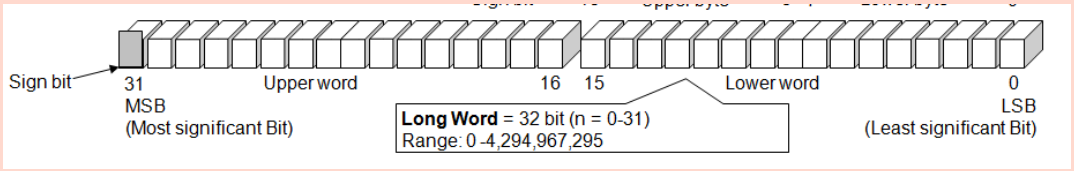
- physical devices used to store data or programs.
- Computer main memory comes in two principal varieties: random-access memory (RAM) and read-only memory (ROM).
- RAM can be read and written to anytime the CPU commands it, but ROM is pre-loaded with data and software that never changes, so the CPU can only read from it.
- ROM is typically used to store the computer's initial start-up instructions.
- In general, the contents of RAM are erased when the power to the computer is turned off, but ROM retains its data indefinitely.
- In a PC, the ROM contains a specialized program called the BIOS that orchestrates loading the computer's operating system from the hard disk drive into RAM whenever the computer is turned on or reset.



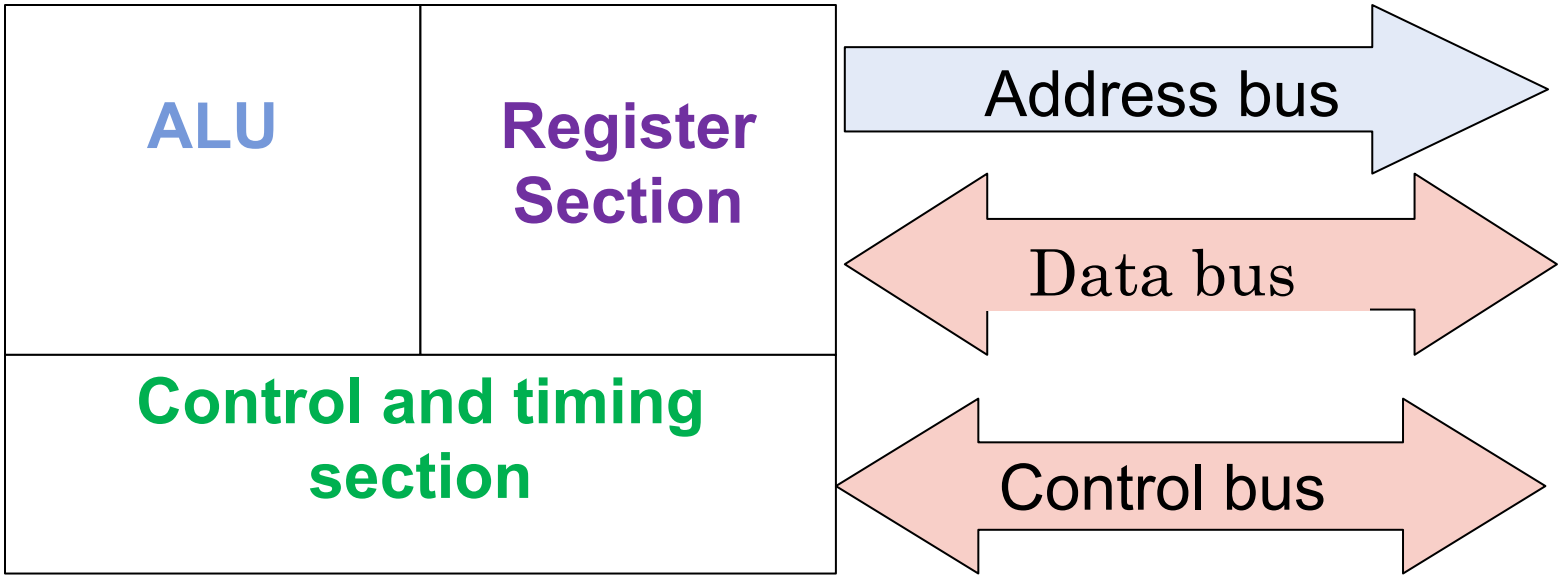
3. I/O Unit

- **Input/output (I/O)**, refers to the communication between an information processing system (such as a computer), and the outside world possibly a human, or another information processing system.
- Inputs are the signals or data received by the system, and outputs are the signals or data sent from it
- Devices that provide input or output to the computer are called peripherals
- On a typical personal computer, peripherals include input devices like the keyboard and mouse, and output devices such as the display and printer. Hard disk drives, floppy disk drives and optical disc drives serve as both input and output devices. Computer networking is another form of I/O.

DATA SIZE

Nibble	**4 bit**	
Byte	**8 bit**	
Word	**16 bit**	
Long word	**32 bit**	

INTERNAL STRUCTURE AND BASIC OPERATION OF MICROPROCESSOR

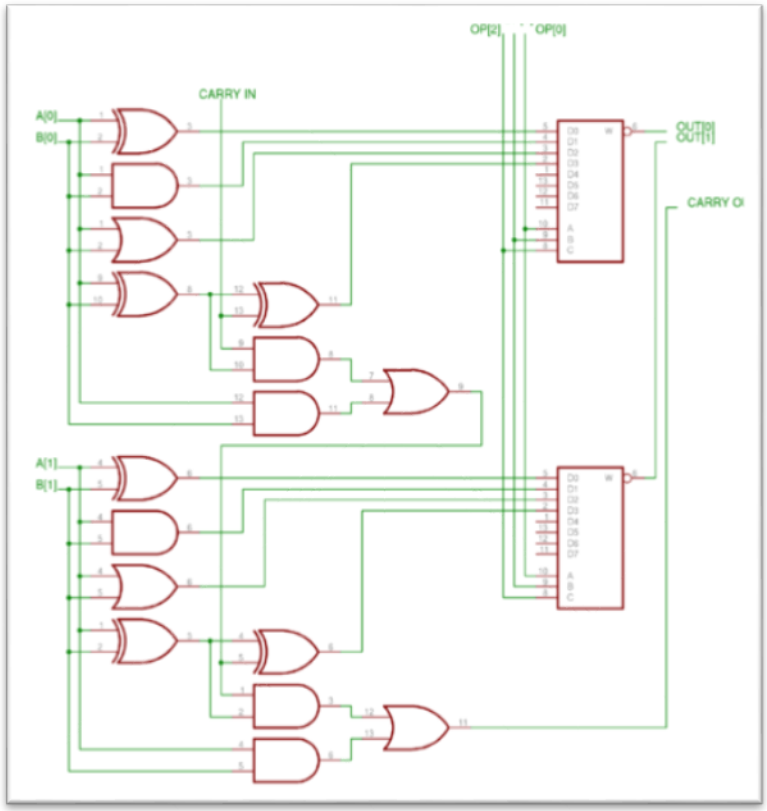


Block diagram of a microprocessor

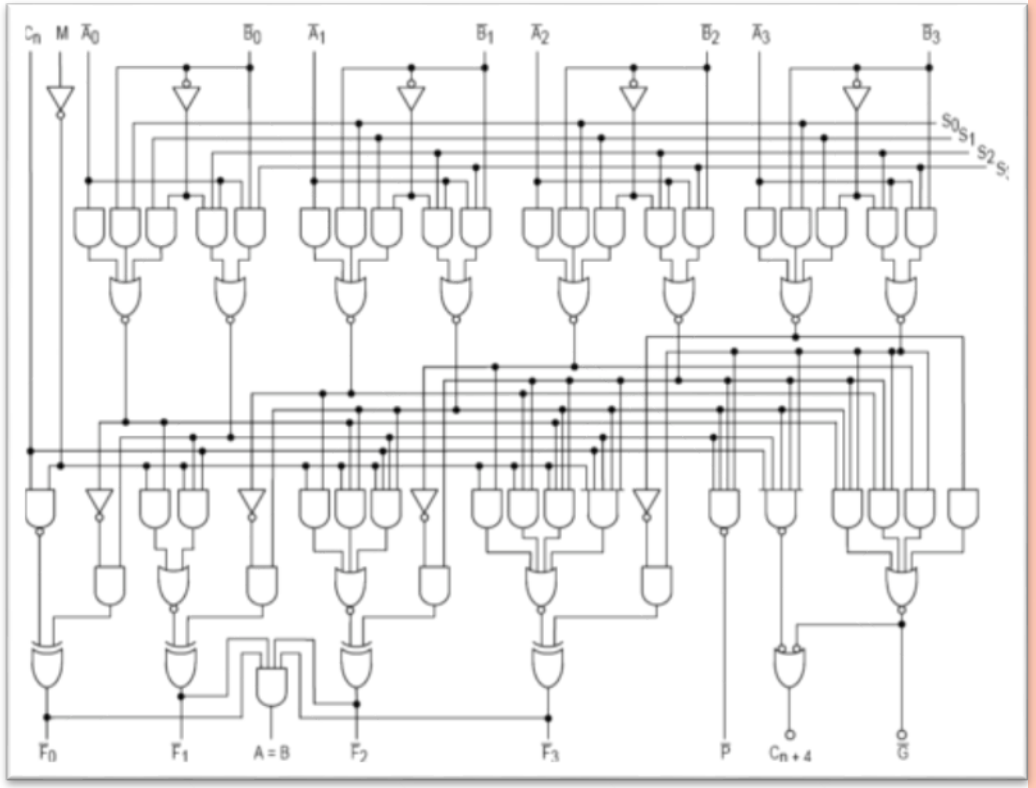
ARITHMETIC AND LOGIC UNIT (ALU)

- The component that performs the arithmetic and logical operations
- the most important components in a microprocessor, and is typically the part of the processor that is designed first.
- able to perform the basic logical operations (AND, OR), including the addition operation.

INTERNAL STRUCTURE OF ALU



2 bits of ALU



4 bits of ALU

CONTROL UNIT

- The circuitry that controls the flow of information through the processor, and coordinates the activities of the other units within it.
- In a way, it is the "brain within the brain", as it controls what happens inside the processor, which in turn controls the rest of the PC.
- On a regular processor, the control unit performs the tasks of fetching, decoding, managing execution and then storing results.

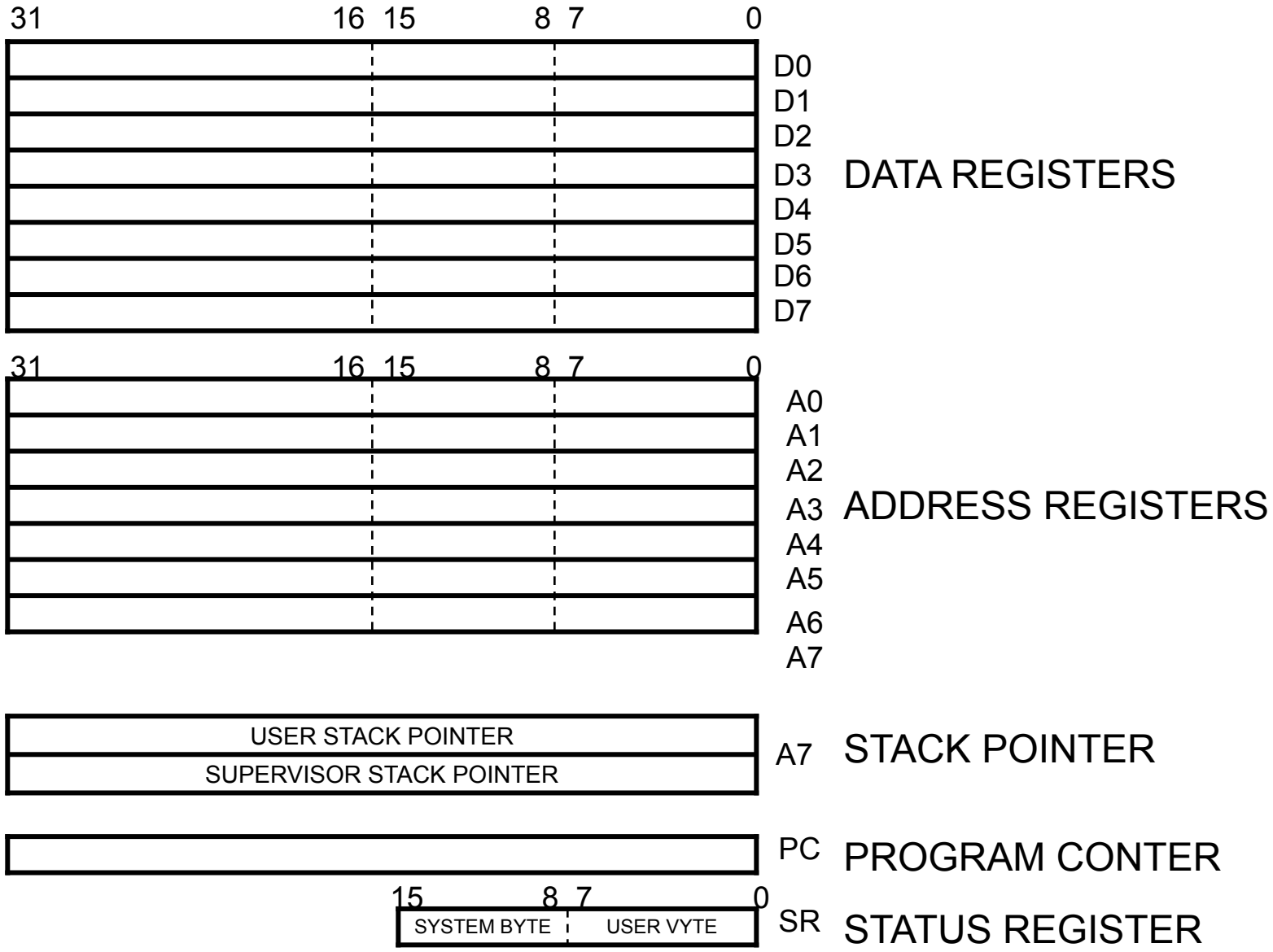
REGISTER SETS

- The register section/array consists completely of circuitry used to **temporarily store data or program codes until they** are sent to the ALU or to the control section or to memory.

- The number of registers are different for any particular CPU and the more register a CPU have will result in easier programming tasks.

- Registers are normally measured by the number of bits they can hold, for example, an "8-bit register" or a "32-bit register".

REGISTER IN MOTOROLA 68000 MICROPROCESSOR



ACCUMULATOR

- a register in which intermediate arithmetic and logic results are stored.
- example for accumulator use is summing a list of numbers.
  - The accumulator is initially set to zero, then each number in turn is added to the value in the accumulator.
  - Only when all numbers have been added is the result held in the accumulator written to main memory or to another, non-accumulator, CPU register.

CONDITION CODE REGISTER (CCR) = FLAGS

- an 8 bit register used to store the status of CPU, such as carry, zero, overflow and half carry.

Flag	Name	Description
Z	Zero flag	Indicates that the result of a mathematical or logical operation was zero.
C	Carry flag	Indicates that the result of an operation produced an answer greater than the number of available bits. (This flag may also be set before a mathematical operation as an extra operand to certain instructions, e.g. "add with carry".)
X	Extend flag	*Masks the XIRQ request when set. It is set by the hardware and cleared by the software as well is set by unmaskable XIRQ.*
N	Negative/ Sign flag	Indicates that the result of a mathematical operation is negative. In some processors, the N and S flags have different meanings: the S flag indicates whether a subtraction or addition has taken place, whereas the N flag indicates whether the last operation result is positive or negative.
V	Overflow Flag	Indicates that the result of an operation has overflowed according to the CPU's word representation, similar to the carry flag but for signed operations.
I	interrupts	Interrupts can be enabled or disabled by respectively setting or clearing this flag. Modifying this flag may be restricted to programs executing in supervisor mode

PROGRAM COUNTER (PC)

- a 16 bit register, used to store the next address of the operation code to be fetched by the CPU.
- Not much use in programming, but as an indicator to user only.
- Purpose of PC in a Microprocessor
  - to store address of tos (top of stack)
  - to store address of next instruction to be executed.
  - count the number of instructions.

STACK POINTER (SP)

- The stack is configured as a data structure that grows downward from high memory to low memory.
- At any given time, the SP holds the 16-bit address of the next free location in the stack.
- The stack acts like any other stack when there is a subroutine call or on an interrupt. ie. pushing the return address on a jump, and retrieving it after the operation is complete to come back to its original location.

DATA BUS

- The data bus is 'bi-directional'
  - data or instruction codes from memory or input/ output.are transferred into the microprocessor
  - the result of an operation or computation is sent out from the microprocessor to the memory or input/output.
- Depending on the particular microprocessor, the data bus can handle 8 bit or 16 bit data.

ADDRESS BUS

- The address bus is '**unidirectional**', over which the microprocessor sends an address code to the memory or input/output.
- The size (width) of the address bus is specified by the number of bits it can handle.
- The more bits there are in the address bus, the more memory locations a microprocessor can access.
- A 16 bit address bus is capable of addressing 65,536 (64K) addresses.

CONTROL BUS

- The control bus is used by the microprocessor to send out or receive timing and control signals in order to coordinate and regulate its operation and to communicate with other devices, i.e. memory or input/output.

MICRO PROCESSOR CLOCK

- Also called clock rate, the speed at which a microprocessor executes instructions. Every computer contains an internal clock that regulates the rate at which instructions are executed and synchronizes all the various computer components.

EXAMPLES OF MICRO PROCESSOR

- Intel 8086
- Motorola 6800
- Zilog Z80

Evolution of Microprocessors

The Microprocessor is nothing but the CPU and it is an essential component of the computer. It is a silicon chip that comprises millions of transistors and other electronic components that process millions of instructions per second. A Microprocessor is a versatile chip, that is combined with memory and special-purpose chips and pre-programmed by software. It accepts digital data as i/p and processes it according to the instructions stored in the memory. The microprocessor has many functions like functions of data storage, interact with various other devices, and other time-related functions. But, the main function is to send and receive the data to make the function of the computer well.

Evolution of Microprocessors

- Transistor was invented in 1948.
- IC was invented in 1958.
- First Microprocessor was invented by INTEL.

First Generation Microprocessors

The first generation microprocessors were introduced in the year 1971-1972. The instructions of these microprocessors were processed serially, they fetched the instruction, decoded and then executed it. When an instruction of the microprocessor was finished, then the microprocessor updates the instruction pointer & fetched the following instruction, performing this consecutive operation for each instruction in turn.

Second Generation Microprocessors

In the year 1970, a small number of transistors were available on the integrated circuit in the second-generation microprocessors. These processors are introduced in the year 1979, and Intel 8080 processor is another example of the microprocessor. The second generation of the microprocessor is defined by overlapped fetch, decode, and execute the steps.

The difference between the first generation microprocessor and second-generation microprocessors was mainly the use of new semiconductor technologies to manufacture the chips. The result of this technology resulted in a fivefold increase in instruction, speed, execution, and higher chip densities.

Third Generation Microprocessors

The third generation microprocessors were introduced in the year 1978, as denoted by Intel's 8086 and the Zilog Z8000. These were 16-bit processors with a performance like mini computers. These types of microprocessors were different from the previous generations of microprocessors.

Fourth Generation Microprocessors

As many industries converted from commercial microprocessors to in house designs, the fourth generation microprocessors are entered with outstanding design with a million transistors. Leading-edge microprocessors like Motorola's 88100 and Intel's 80960CA could issue & retire more than one instruction per clock cycle.

Fifth Generation Microprocessors

Fifth-generation microprocessors employed decoupled superscalar processing, and their design soon exceeded 10 million transistors. In the fifth generation, PCs are a low-margin, high volume business conquered by a single microprocessor.

Types of Microprocessors

- ## 4-bit Microprocessor

  The INTEL 4004/4040 was invented in the year 1971 by Stanley Mazor & Ted Hoff. The clock speed of this microprocessor is 740 KHz. The number of transistors used in this microprocessor is 2,300 and instruction per second is 60K. The number of pins of this microprocessor is 16.

8-bit Microprocessor

i) The 8008 processor was invented in the year 1972. The clock speed of this microprocessor is 500 KHz and instruction per second is 50K

ii) The 8080 microprocessor was invented in the year 1974. The clock speed is 2 MHz. The number of transistors used is 60k and instruction per second is 10 times quicker as compared with 8008 processor.

iii) The 8085 microprocessor was invented in the year 1976. The clock speed is 3 MHz. The number of transistors used is 6,500 and instruction per second is 769230. The number of pins of this microprocessor is 40.

16-bit Microprocessor

The 8086 microprocessor was invented in the year 1978. The clock speed is 4.77, 8 & 10 MHz. The number of transistors used is 29000 and instruction per second is 2.5 Million. The number of pins of this microprocessor is 40

The 8088 microprocessor was invented in the year 1979 and instruction per second is 2.5 Million

The microprocessors like 80186 or 80188 were invented in the year 1982. The clock speed is 6 MHz

The 80286 microprocessor was invented in the year 1982. The clock speed is 8 MHz. The number of transistors used is 134000 and instruction per second is 4 Million. The number of pins of this microprocessor is 68

32-bit Microprocessor

- The Intel 80386 microprocessor was invented in the year 1986. The clock speed is 16 MHz to 33 MHz. The number of transistors used is 275000. The number of pins of this microprocessor is 132 14X14 PGA.
- The Intel 80486 microprocessor was invented in the year1986. The clock speed is 16MHz to 100 MHz. The number of transistors used is 1.2 Million transistors and instruction per second is 8 KB of cache memory. The number of pins of this microprocessor is 168 17X17 PGA (Pin Grid Array).
- The PENTIUM microprocessor was invented in the year 1993. The clock speed is 66 MHz and instruction per second is Cache memory 8-bit for instructions 8- bit for data. The number of pins of this microprocessor is 237 PGA.

64-bit Microprocessor

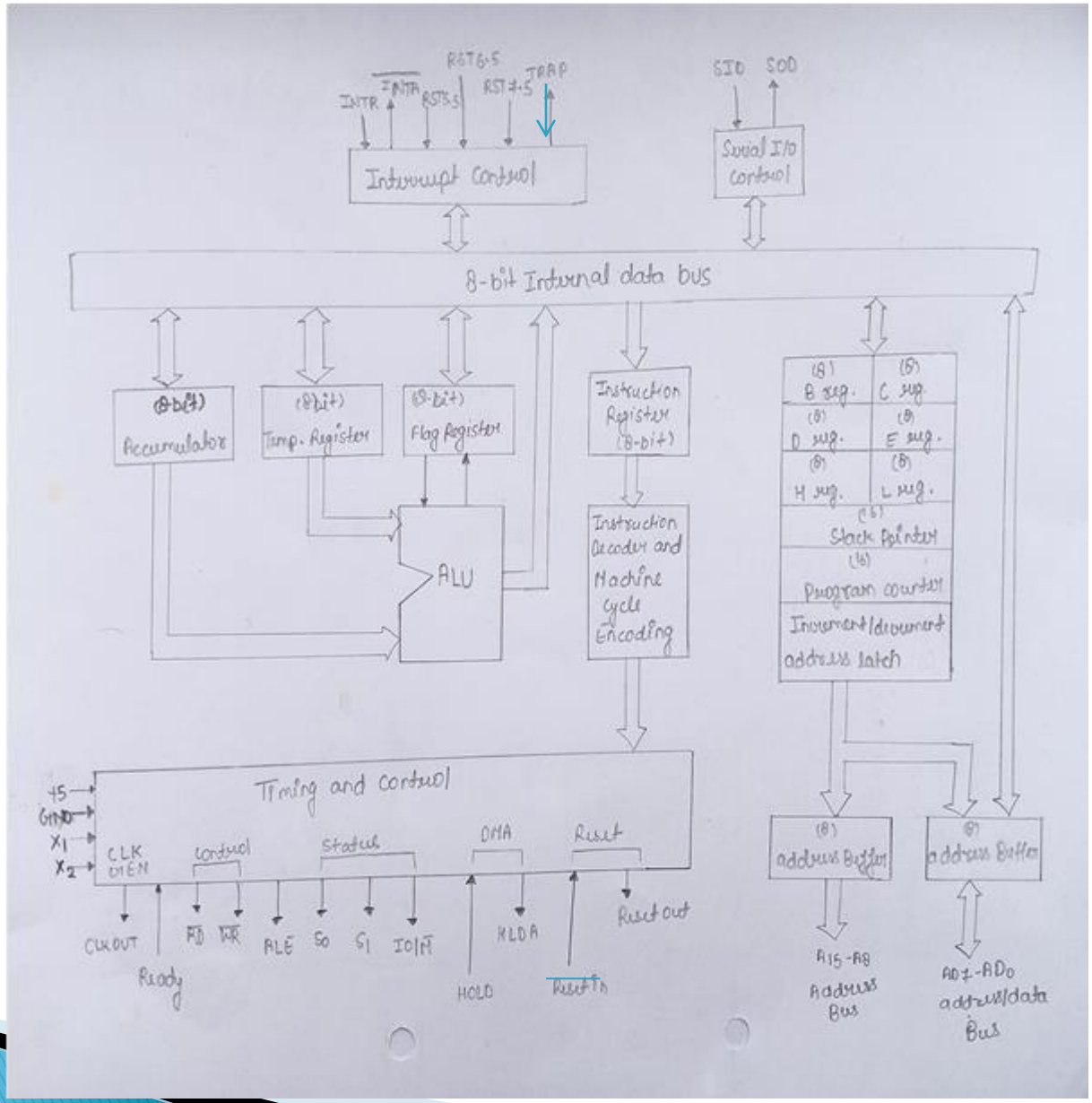
- The INTEL core 2 microprocessor was invented in the year 2006. The clock speed is 1.2 GHz to 3 GHz. The number of transistors used is 291 Million and instruction per second is 64 KB of L1 cache for each core 4 MB of L2 cache.
- The i3, i5, i7 microprocessors were invented in the years 2007, 2009, 2010. The clock speed is 2GHz to 3.3GHz, 2.4GHz to 3.6GHz & 2.93GHz to 3.33GHz.

MICROPROCESSOR-8085

FEATURES

- It is a 40 pin IC.
- It is an 8-bit processor.
- 8-bit Data bus ie; D_0 – D_7.
- 16-bit Address bus ie; A_0 – A_{15}.
- Operating CLK Freq around 3 MHz.
- Maximum memory that can be interfaced with 8085 is 64 KB.

Functional Block Diagram



Architecture of Microprocessor – 8085

The Architecture of Processor 8085 is Block wise. The description of various Blocks are as follows –

- **ALU (Arithmetic Logic Unit)**

All the arithmetic and logical operations are performed in this unit.Such as addition, subtraction, compliments, ANDing, ORing, X-ORing etc.

- **Accumulator**
  - It is an 8- bit register.
  - During the arithmetic or logic operations one of the operand comes from the accumulator.
  - The result of the arithmetic or logic operations is also stored in the accumulator.
- **Temporary Register**
  - W, X and Z are the temporary registers of 8085.
  - Capacity of each register is 8- bit.
  - These registers are used by microprocessor itself for interface operations.

Flag Register

- It is an 8- bit register but only five bits are used.
- It is also called Program Status Word (PSW).

S	Z	X	AC	X	P	X	CY

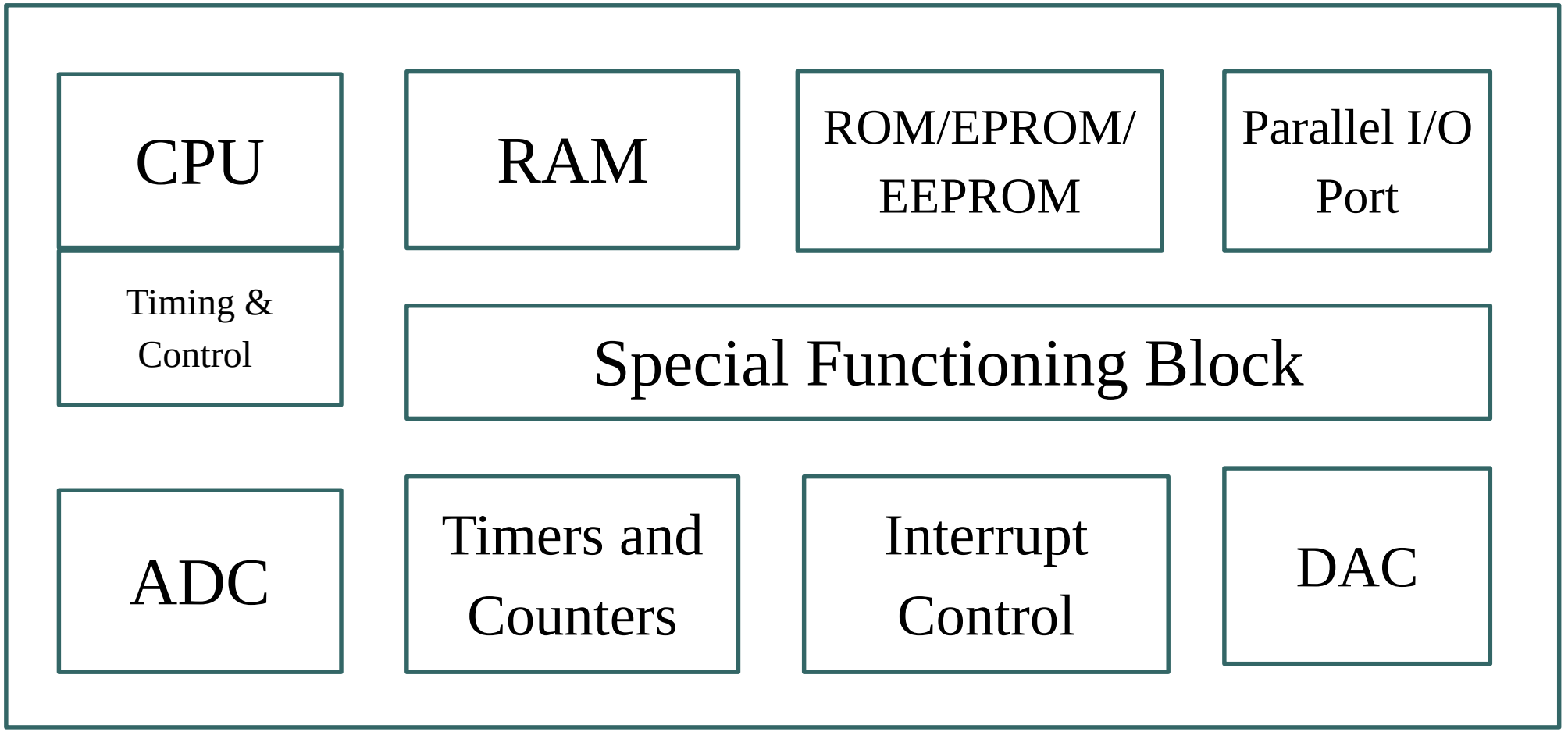
Program Status Word

- **S** → Sine Flag
- **Z** → Zero Flag
- **AC** → Auxiliary Carry Flag
- **P** → Parity Flag
- **CY** → Carry Flag.

Introduction

- A microcontroller is an electronic device belonging to the microcomputer family.
- These are fabricated using the VLSI (**V**ery **L**arge **S**cale **I**ntegration) technology on a single chip.
- Microcontroller is also known as “Computer-on-a-Chip”.
- It is named so, because not only the CPU, but RAM, ROM, I/O ports, Timer/Counter, Serial I/Os all are put together on a single microcontroller chip.
- A microcontroller also called an embedded controller because the microcontroller and its support circuits are often built into, or embedded in, the devices they control.
- A microcontroller is available in different word lengths like microprocessors (4bit, 8bit, 16bit, 32bit, 64bit and 128-bit microcontrollers are available today).

Block Diagram of Microcontroller



Memory

- Memory spaces such as RAM, ROM, EPROM or EEPROM are there to store data and programs.
- For data storage, volatile memory RAM is used while for the program and operating parameter storage ROM and other memory spaces are used.
- A microcontroller usually has a certain amount of RAM and ROM (EEPROM, EPROM, etc) or flash memories for storing program source codes.

Timers/counters

- This is the one of the useful function of a microcontroller.
- A microcontroller may have more than one timer and counters.
- The timers and counters provide all timing and counting functions inside the microcontroller.
- The major operations of this section are performed clock functions, modulations, pulse generations, frequency measuring, making oscillations, etc.
- This also can be used for counting external pulses.
- There is a watchdog timer. A watchdog timer is a portion of hardware that can be used to automatically detect software anomalies/malfunctions and reset the processor if any occur

Parallel input/output ports

- Parallel input/output ports are mainly used to drive/interface various devices such as LCD’S, LED’S, printers, memories, etc to a microcontroller.

Serial ports

- Serial ports provide various serial interfaces between a microcontroller and other peripherals like parallel ports.

Interrupt control

- The interrupt control used for providing interrupt (delay) for a working program.
- The interrupt may be external (activated by using interrupt pin) or internal (by using interrupt instruction during programming).

Special functioning block

- Some microcontrollers used only for some special applications (e.g. space systems and robotics) these controllers containing additional ports to perform such special operations.
- This considered as special functioning block.

Analog to Digital Converter (ADC)

- ADC converters are used for converting the analog signal to digital form.
- The input signal in this converter should be in analog form (e.g. sensor output) and the output from this unit is in digital form.
- The digital output can be used for various digital applications (e.g. measurement devices).

Digital to Analog Converter (DAC)

- DAC perform reversal operation of ADC conversion. DAC converts the digital signal into analog format.
- It usually used for controlling analog devices like DC motors, various drives, etc.

Advantages of microcontroller

- The main advantages of microcontrollers are given.
- Microcontrollers act as a microcomputer without any external digital parts.
- As the higher integration inside microcontroller reduces cost and size of the system.
- Usage of a microcontroller is simple, easy to troubleshoot and system maintaining.
- Most of the pins are programmable by the user for performing different functions.
- Easily interface additional RAM, ROM, I/O ports.
- Low time required for performing operations.

Disadvantages of Microcontrollers

- Microcontrollers have got more complex architecture than that of microprocessors.
- Microcontrollers are used for dedicated application only.
- Only perform a limited number of executions simultaneously.
- Mostly used in micro-equipment.
- Cannot interface high power devices directly.

Comparison between microprocessor and microcontroller

Sr. No.	Microprocessors	Microcomputer
1	It is only a general purpose computer CPU	It is a microcomputer itself
2	Memory, I/O ports, timers, interrupts are not available inside the chip	All are integrated inside the microcontroller chip
3	Systems become bulkier and expensive.	Make the system simple, economic and compact
4	Microprocessors have many opcodes for moving the data from external memory to CPU.	Microcontrollers have one or two opcodes for moving the data.
5	Higher accessing time required	Low accessing time
6	Very few number of bit handling instructions	Many bit handling instructions
7	Very few pins are programmable	Most of the pins are programmable
8	Widely Used in modern PC and laptops	widely used in small control systems and dedicated applications
9	E.g. INTEL 8086, INTEL Pentium series etc.	E.g. INTEL8051, 89960, PIC16F877 etc.

Applications of microcontroller

- **1. Consumer Electronics Products:**
  - Toys, Cameras, Robots, Washing Machine, Microwave Ovens etc. [any automatic home appliance]
- **2. Instrumentation and Process Control:**
  - Oscilloscopes, Multi-meter, Leakage Current Tester, Data Acquisition and Control etc.
- **3. Medical Instruments:**
  - ECG machine, Electronic Cardiac Monitor, Blood gas analyzer, Blood Glucose Monitor, MRI Machine etc.
- **4. Communication:**
  - Cell Phones, Telephone Sets, Answering Machines etc.
- **5. Office Equipment:**
  - Fax, Printers, etc.
- **6. Multimedia Application:**
  - Mp3 Player, PDAs, optical players, digital camcorders etc.
- **7. Automobile:**
  - Speedometer, Auto-breaking system etc.
- **8. Robotics:**
  - Domestic or household robots, Industrial robots, Medical robots, Service robots, Military robots, Entertainment robots, Space robots,

GPU

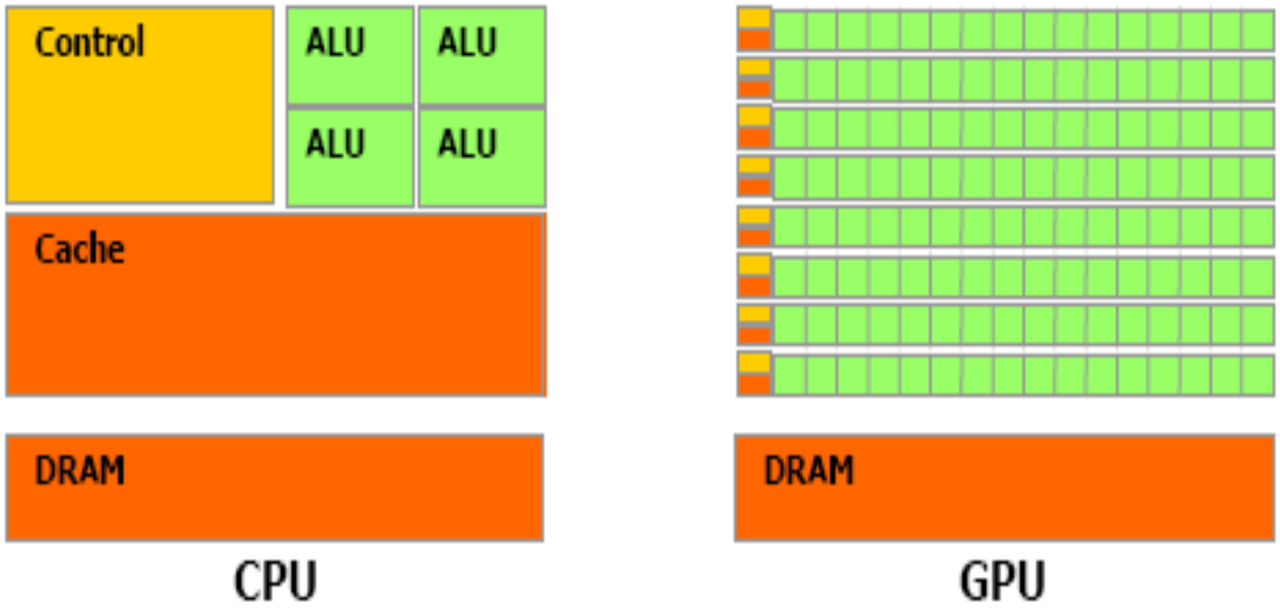
- What is GPGPU?
  - General-Purpose computing on a Graphics Processing Unit
  - Using graphic hardware for non-graphic computations

- Prefect for massive parallel processing on data paralleled applications

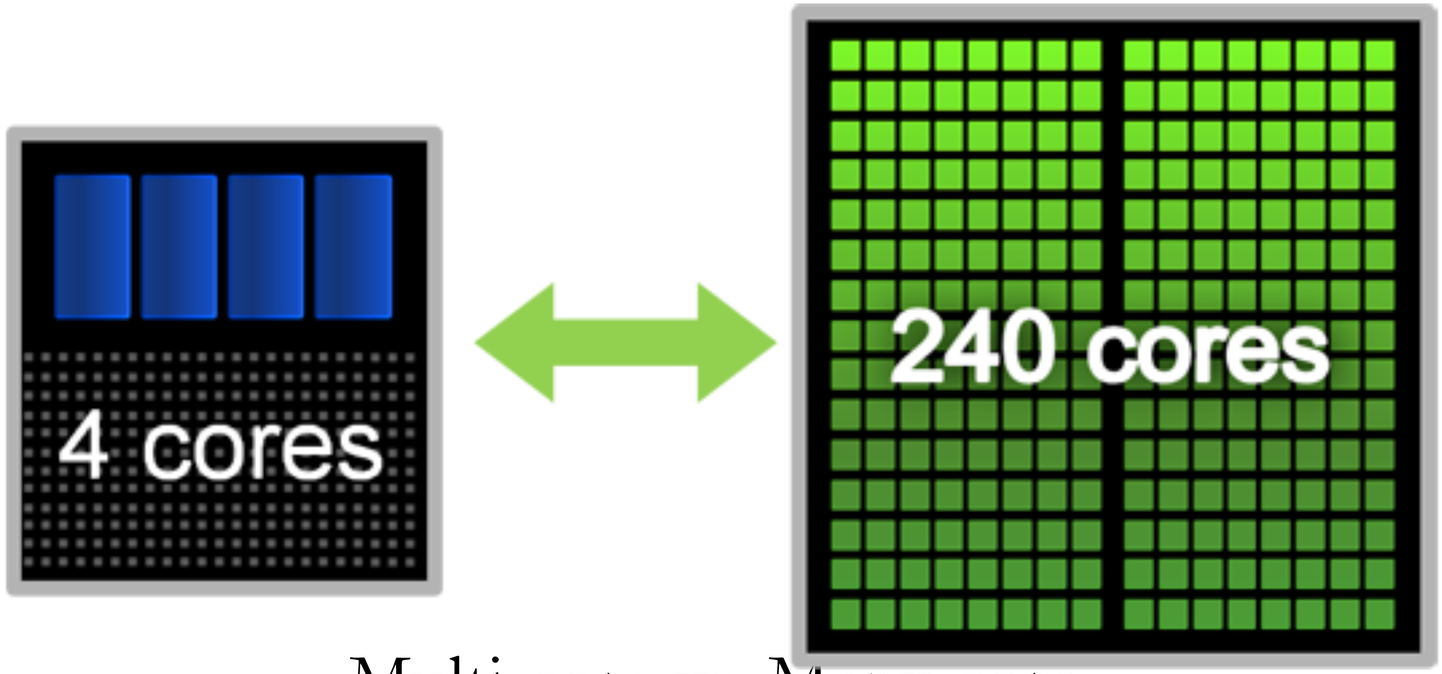
GPU vs CPU

- A GPU is tailored for highly parallel operation while a CPU executes programs serially
- For this reason, GPUs have many parallel execution units and higher transistor counts, while CPUs have few execution units and higher clockspeeds
- GPUs have much deeper pipelines (several thousand stages vs 10-20 for CPUs)
- GPUs have significantly faster and more advanced memory interfaces as they need to shift around a lot more data than CPUs

CPU vs. GPU - Hardware



CPU vs. GPU - Hardware



Multi-core vs. Many-core