CSE 331
Microprocessor Interfacing and Embedded System

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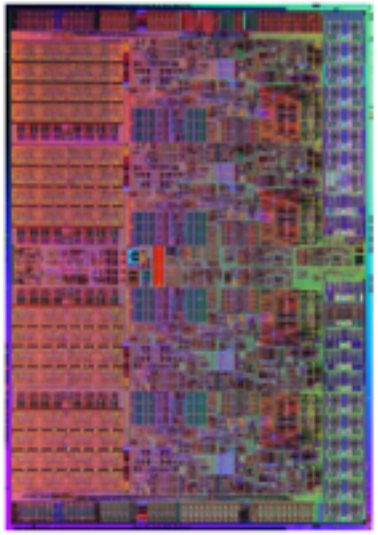
Background and History

What is a Microprocessor?

- Microprocessor is a computer Central Processing Unit (CPU) on a single chip.
- It contains millions of transistors connected by wires



Core i7 die

Picture: Intel

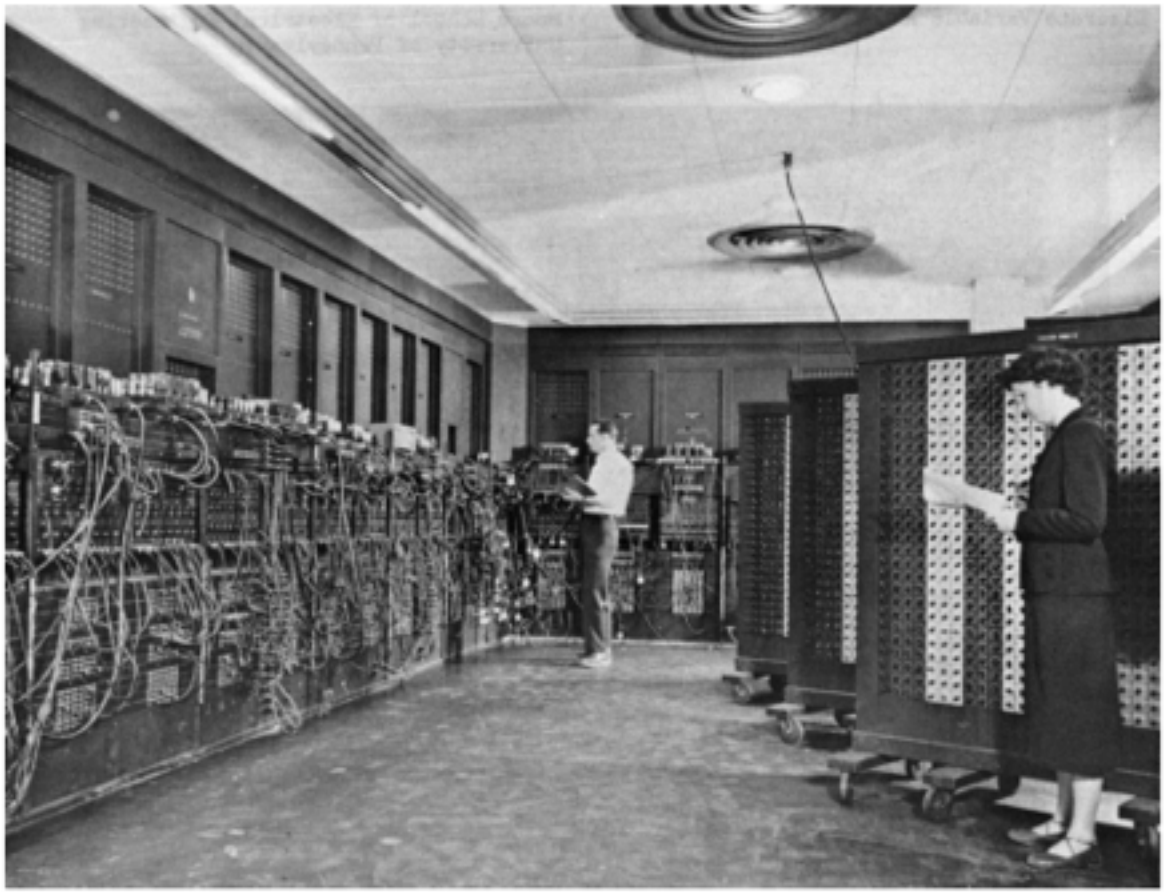
Core i7 in package

Picture: Ebbesen

Electrical Numerical Integrator and Calculator

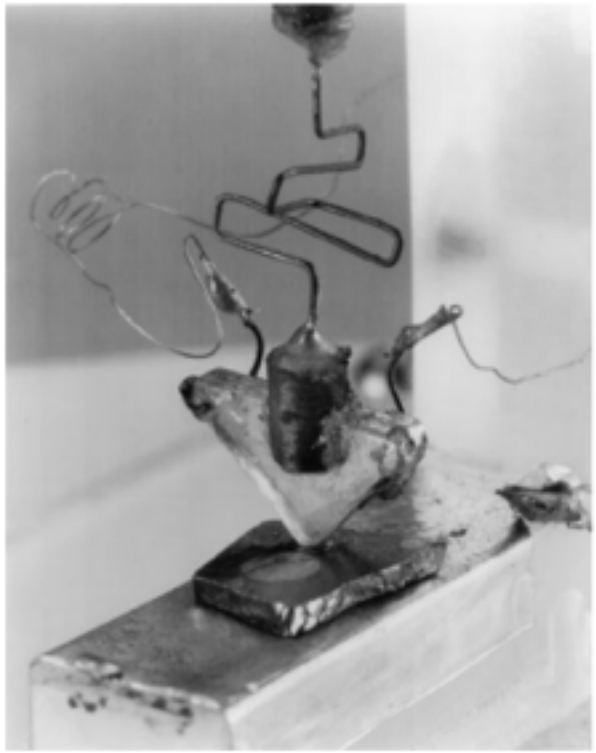
- Designed for the U.S. Army's Ballistic Research Laboratory
- Built out of
  - 17,468 vacuum tubes
  - 7,200 crystal diodes
  - 1,500 relays
  - 70,000 resistors
  - 10,000 capacitors
- Consumed 150 kW of power
- Took up 72 m^2
- Weighted 27 tons
- Suffered a failure on average every 6 hours

Electrical Numerical Integrator and Calculator



Glen Beck and Betty Snyder program the ENIAC in BRL building 328. (Picture: U.S. Army)

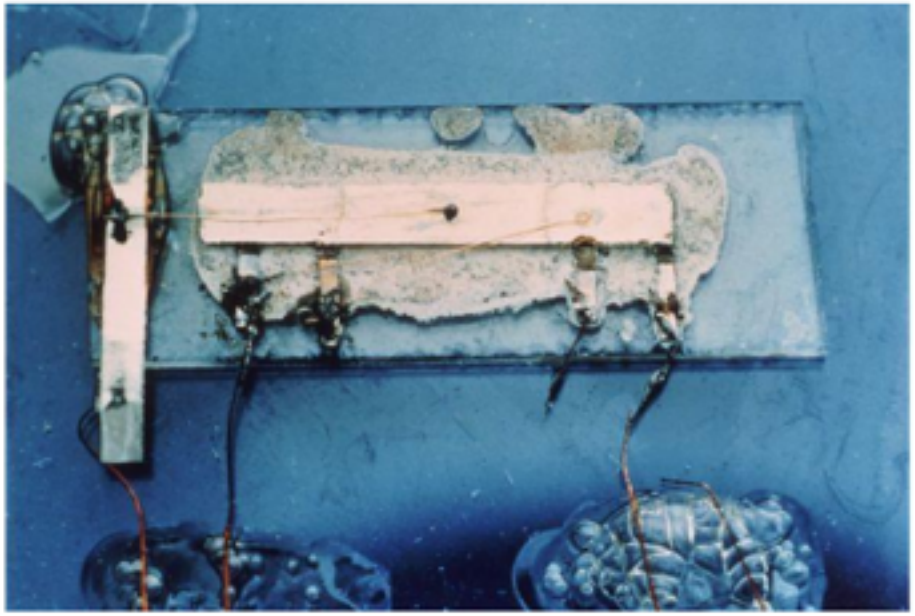
The First Transistor was Created in 1947



- Used germanium
- Created by a team lead by William Shockley at Bell Labs
- Shockley later shared the Noble prize in physics
- Shockley semiconductors was founded in Palo Alto in 1955
- In 1957 Bob Noyce, Gordon Moore, and 6 others ("Traitorous Eight") leave to found Fairchild semiconductor

The First Integrated Circuit was Created in 1959

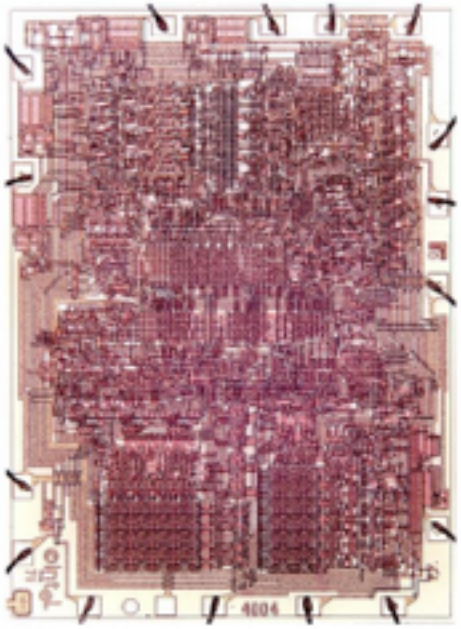
- Proposed independently by Bob Noyce at Fairchild and Jack Kilby at Texas Instruments
- In 1968 Noyce and Moore leave Fairchild to found Intel
- Contained a single transistor and supporting components



The first working integrated circuit (1.6 × 11.1 mm)
Picture: TI

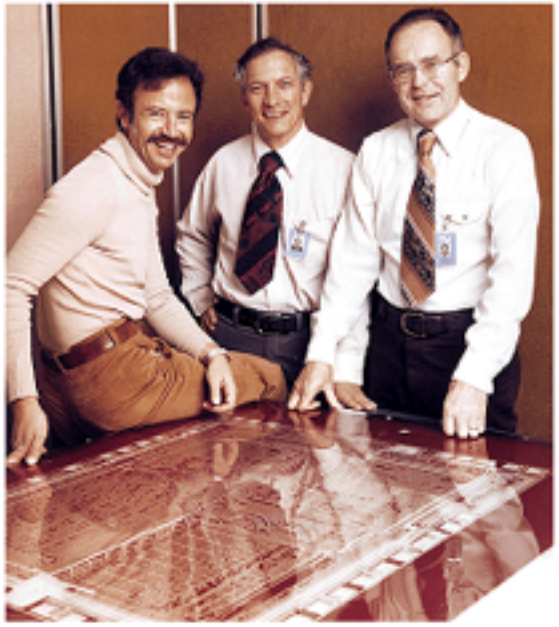
Intel Created the First Commercial Microprocessor

- Introduced the 4004 in 1971, contained 2,300 transistors
- Had roughly the same processing power as ENIAC



Intel 4004

Picture: Intel



Intel founders (circa 1978)

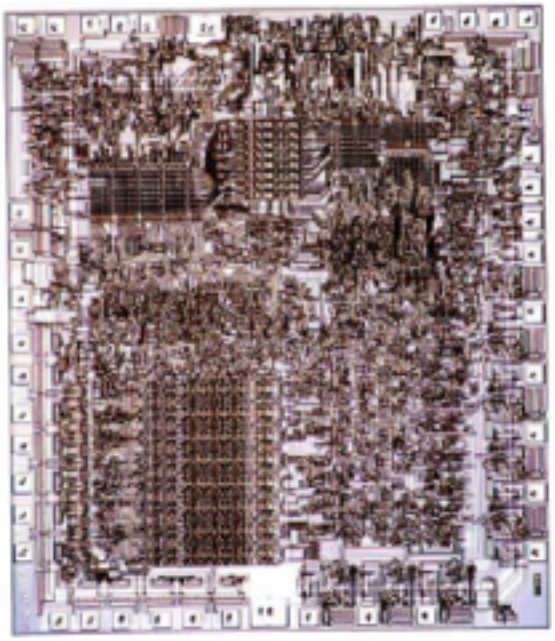
Picture: Intel

IBM Introduced its Original PC in 1981

- Used the Intel 8088 processor containing 29,000 transistors
- Used operating system (MS-DOS) designed by Microsoft

IBM PC

Picture: Intel



Intel 8088

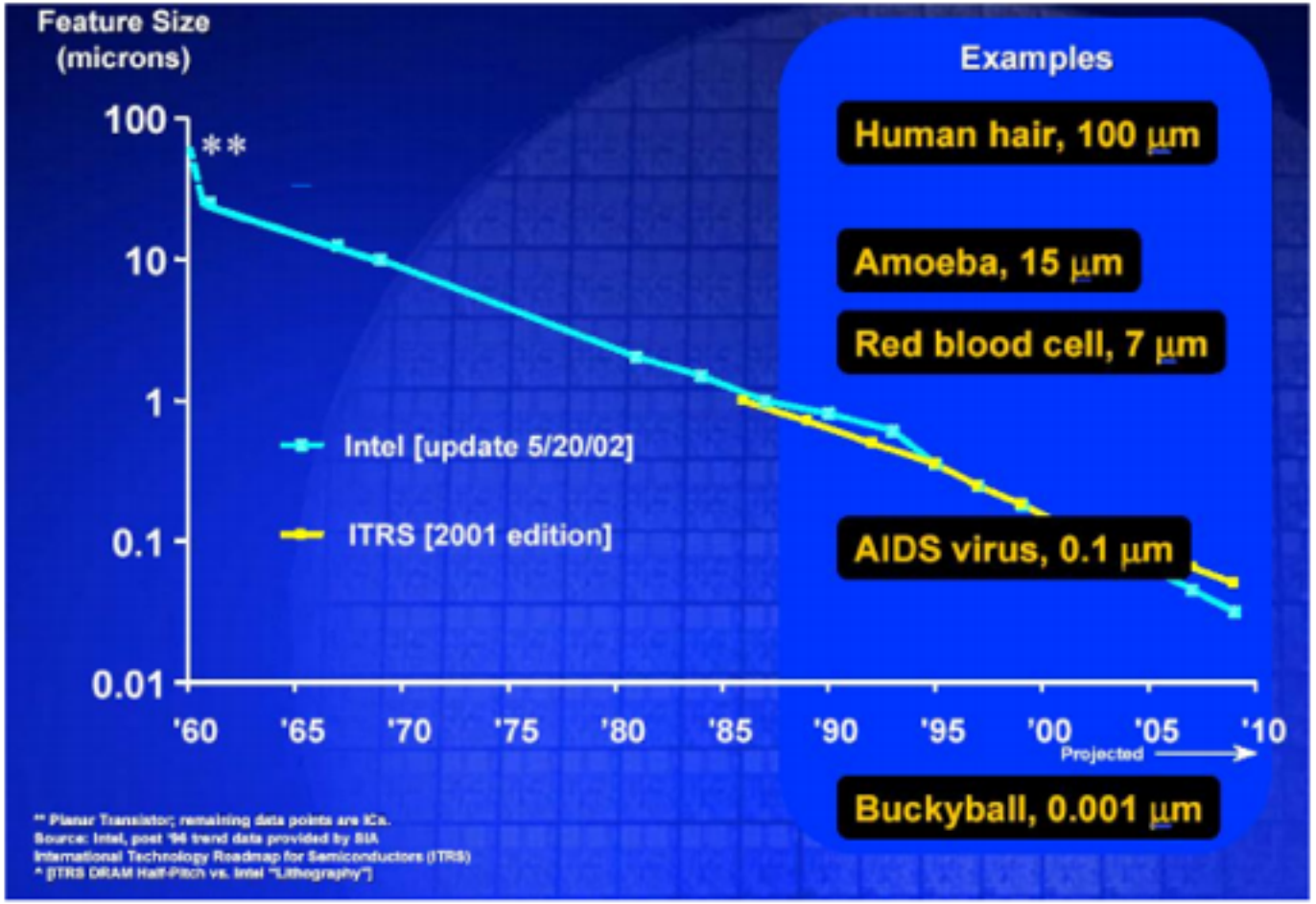
Picture: Intel

Microprocessor Evolution

- 4004 transistors were 10 μm across
- Pentium 4 transistors are 0.13 μm across
- Human hair is about 100 μm across

- Smaller transistors allow
  - More transistors per chip
  - More processing per clock cycle
  - Faster clock rates
  - Smaller/cheaper chips

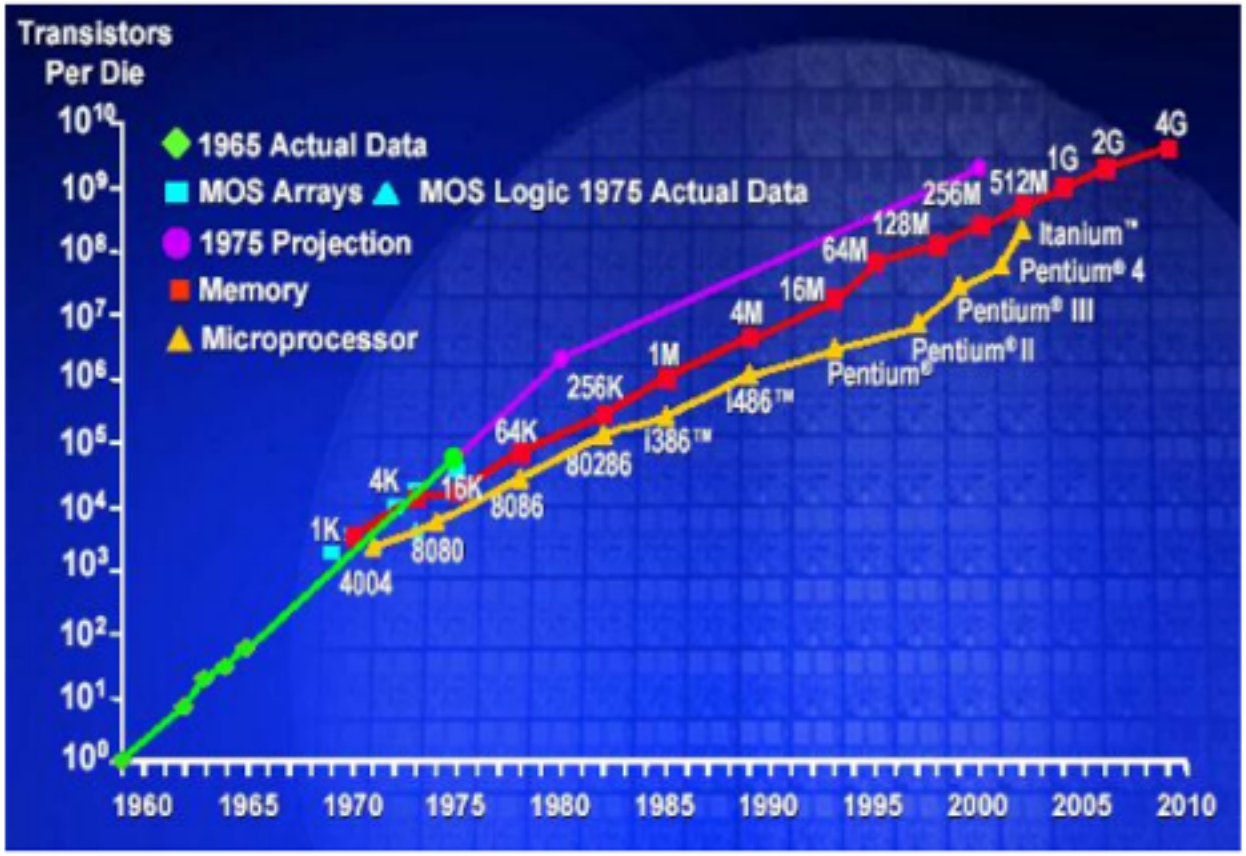
Microprocessor Evolution



Picture: Intel

Moore's Law

- "The number of transistors incorporated in a chip will approximately double every 24 months." (1965)



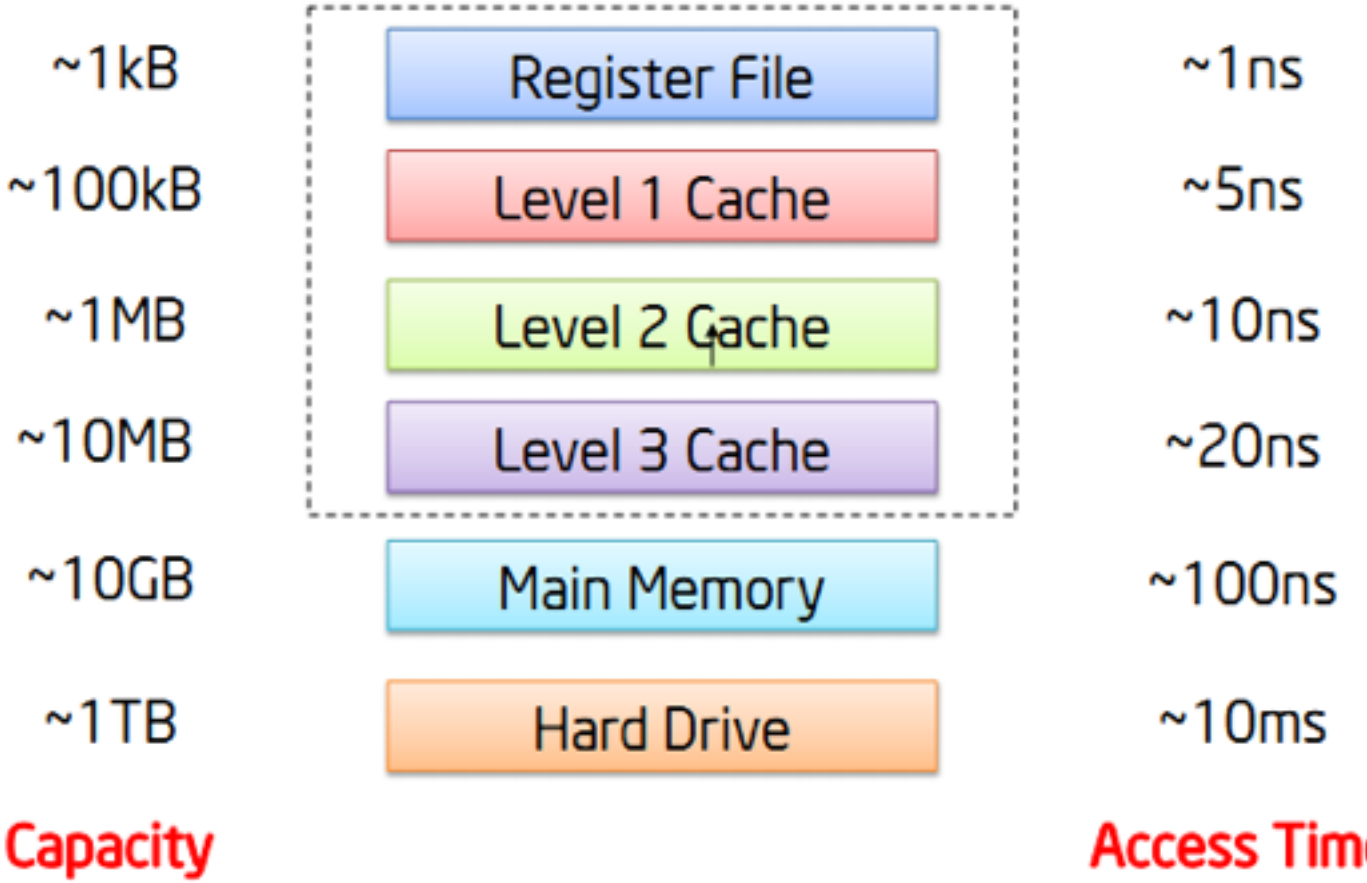
Picture: Intel

Computer Components

PC Components

- Microprocessor — performs all computations
- Cache — fast memory which holds current data and program
- Main memory — larger DRAM memory contains more data
- Chipset — controls communication between components
- Motherboard — circuit board which holds all the above components
- Peripheral cards — controls added computer accessories

Memory Hierarchy

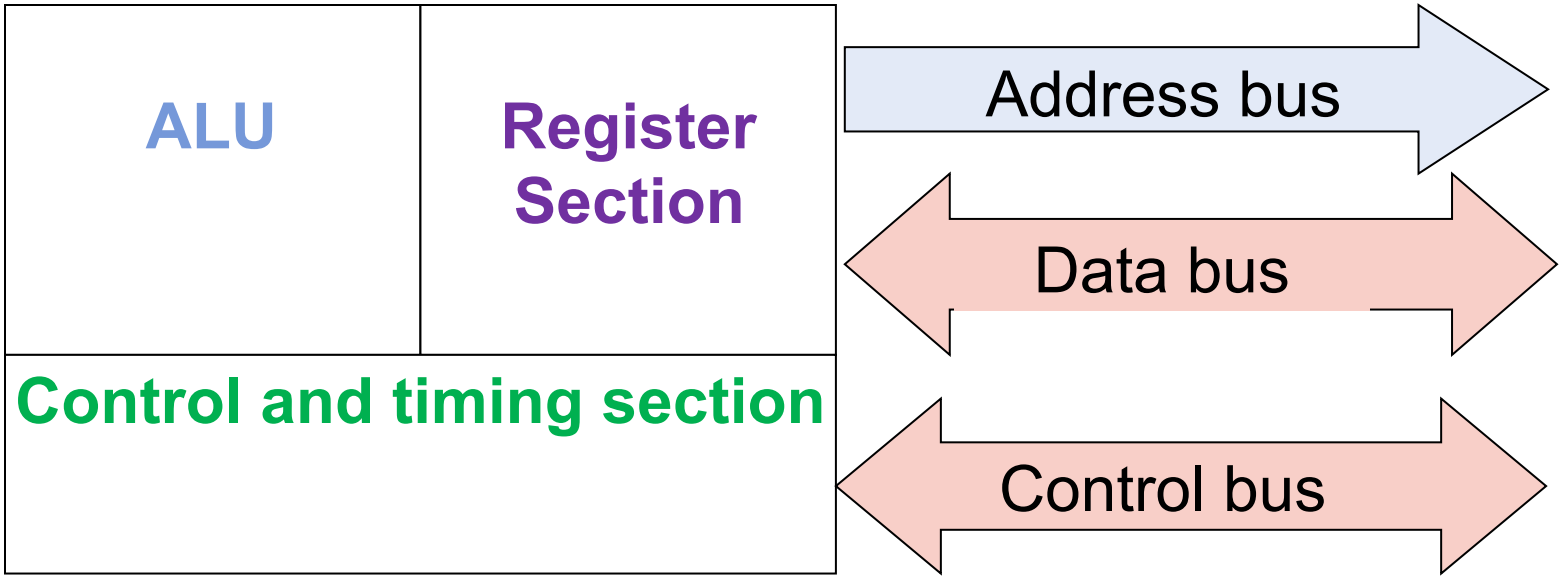


Microprocessor Architecture

What is Architecture?

- Computer architecture is defined by the instructions a processor can execute
- Programs written for one processor can run on any other processor of the same architecture
- Current architectures include:
  - IA32 (x86)
  - IA64
  - ARM
  - PowerPC
  - SPARC

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.

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".

System Bus

The MPU communicates with Memory and I/O using the **System Bus**

- **Address bus**
  - Unidirectional
- **Data bus**
  - Bidirectional
- **Control lines**
  - Read and Write timing signals

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.
- The CPU requires a fixed number of clock ticks (or clock cycles) to execute each instruction. The faster the clock, the more instructions the CPU can execute per second. Clock speeds are expressed in megahertz (MHz) or gigahertz ((GHz).

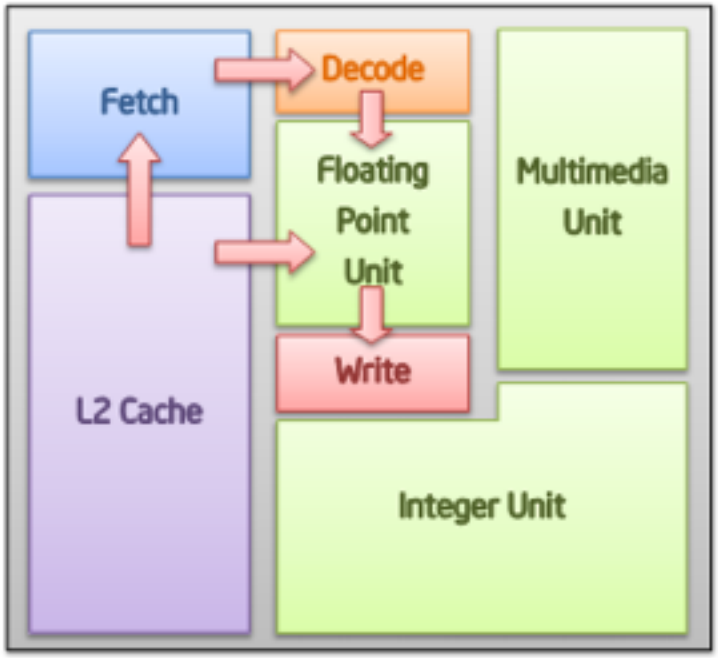
What are Instructions?

- Instructions are the most basic actions the processor can take:
  - ADD AX, BX — Add value AX to BX and store in AX
  - CMP AX, 5 — Compare value in AX to 5
  - JE 16 — Jump ahead 16 bytes if comparison was equal
- High level programming languages (C, C++, Java) allow many processor instructions to be written simply:
  - if (A + B = 5) then... — Jump if sum of A and B is 5
- Every program must be converted to the processor instructions of the computer it will be run on

Working Steps of a CPU

- **Instruction fetch**
- **Instruction Decode**
- **Operand Fetch**
- **Execute**
- **Store**
- **Next Instruction**

Simplified Microprocessor



Fetch Unit gets the next instruction from the cache.

Decode Unit determines type of instruction.

Instruction and data sent to Execution Unit.

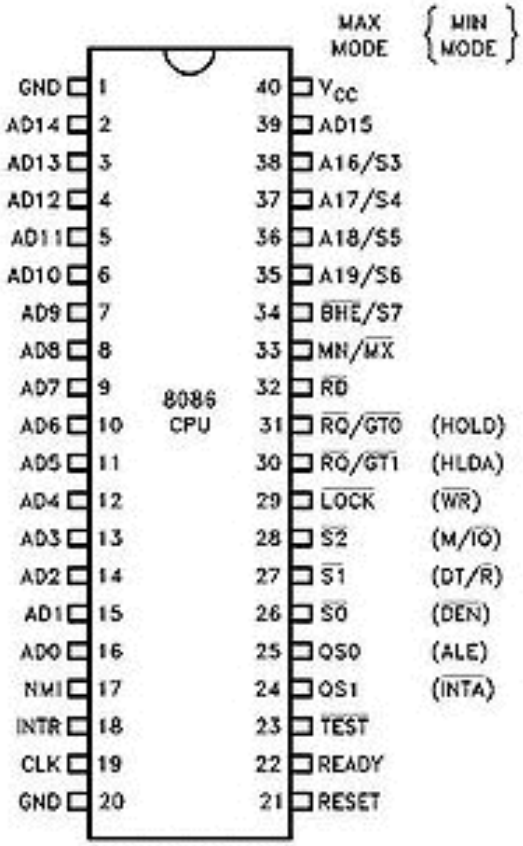
Write Unit stores result.

Examples of micro processor

- Intel 8085
- Intel 8086

8086

- The 8086 is a 16-bit microprocessor chip designed by Intel, which gave rise to the x86 architecture; development work on the 8086 design started in the spring of 1976 and the chip was introduced to the market in the summer of 1978.
- The Intel 8088, released in 1979, was a slightly modified chip with an external 8-bit data bus (allowing the use of cheaper and fewer supporting logic chips and is notable as the processor used in the original IBM PC.



8085

- The Intel 8085 is an 8-bit microprocessor introduced by Intel in 1977.
- It was binary-compatible with the more-famous Intel 8080 but required less supporting hardware, thus allowing simpler and less expensive microcomputer systems to be built.

An Intel 8085AH processor.	
Produced	From 1977 to 1990s
Common manufacturer(s)	•Intel and several others
Max. CPU clock rate	3,5 and 6 MHz
Instruction set	pre x86
Package(s)	•40 pin DIP