NEUB CSE 321 Lecture 1: Introduction

Processor

In computing, a processor or processing unit is an electronic circuit which performs operations on some external data source, usually memory or some other data stream.

Microprocessor (µ P) !!??!!

There are many common reasons to call today's microprocessor a microprocessor.

The 1960s saw the emergence of the "minicomputer" - machine like the DEC PDP-8 and PDP-11 and the Computer Technology Modular One. These were small (for the time), cheap (for the time) computers, in contrast to the large "mainframe" of the day.

When semiconductor technology reached the level of integration that the CPU of a computer (i.e. only the CPU - not the memory, nor the i/o system) could be implemented on a single-chip, it became possible to build very cheap, very small computers. These computers were called microcomputers (in the sequence "computer", "minicomputer", "microcomputer"). The single chip CPU was called "microprocessor" to indicate that it wasn't a complete computer. The term "microcomputer" was used to describe complete computers on a chip - memory and I/O included.

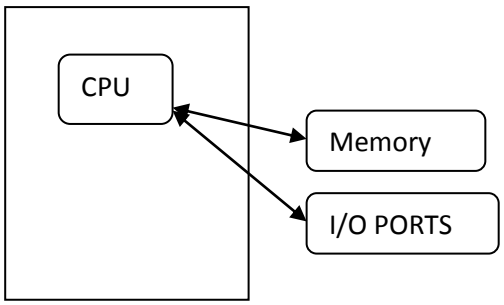
Another reason for the name 'Microprocessor' comes on the basis of its processing speed. For example, consider 8085 microprocessor , it's operating frequency is 3MHz, so naturally it's time period will be 1/T, which comes in microseconds.

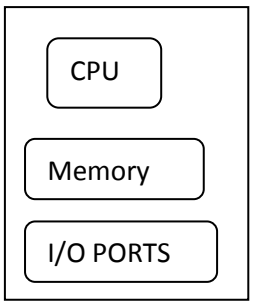
Microprocessor Vs Microcontroller

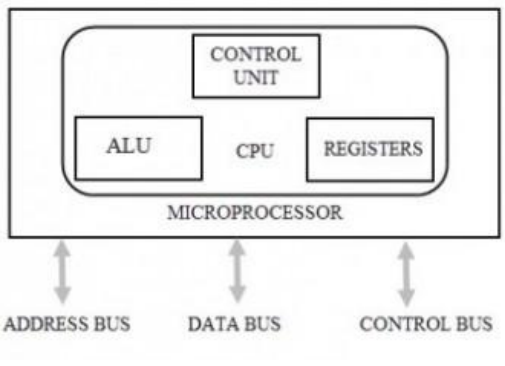
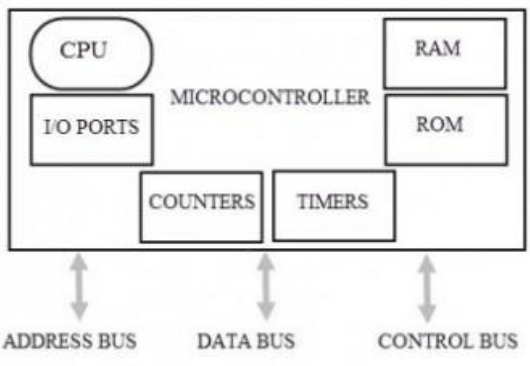
Microprocessor is the brain of any computer. It is only a part of computer and no matter how much powerful it is it cannot function without any additional components or circuitry.

A microcontroller can be thought as a fully functional body with all the muscles necessary to live through the tough world, no matter how small it is. A microcontroller is basically a small computer with all the necessary circuitry inside to function as a computing unit.

The first commercial Microprocessor was released by Intel in year 1971 November named as 4004 (four – thousand – four). It is 4-bit microprocessor.





Microprocessor	Microcontroller
	

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Microprocessor assimilates the function of a central processing unit (CPU) on to a single integrated circuit (IC).	Microcontroller can be considered as a small computer which has a processor and some other components in order to make it a computer.
Microprocessors are mainly used in designing general purpose systems from small to large and complex systems like super computers.	Microcontrollers are used in automatically controlled devices.
Microprocessors are basic components of personal computers.	Microcontrollers are generally used in embedded systems
Computational capacity of microprocessor is very high. Hence can perform complex tasks.	Less computational capacity when compared to microprocessors. Usually used for simpler tasks.
A microprocessor based system can perform numerous tasks.	A microcontroller based system can perform single or very few tasks.
Microprocessors have integrated Math Coprocessor. Complex mathematical calculations which involve floating point can be performed with great ease.	Microcontrollers do not have math coprocessors. They use software to perform floating point calculations which slows down the device.
The main task of microprocessor is to perform the instruction cycle repeatedly. This includes fetch, decode and execute.	In addition to performing the tasks of fetch, decode and execute, a microcontroller also controls its environment based on the output of the instruction cycle.
In order to build or design a system (computer), a microprocessor has to be connected externally to some other components like Memory (RAM and ROM) and Input / Output ports.	The IC of a microcontroller has memory (both RAM and ROM) integrated on it along with some other components like I / O devices and timers.
The overall cost of a system built using a microprocessor is high. This is because of the requirement of external components.	Cost of a system built using a microcontroller is less as all the components are readily available.
Generally power consumption and dissipation is high because of the external devices. Hence it requires external cooling system.	Power consumption is less.
The clock frequency is very high usually in the order of Giga Hertz.	Clock frequency is less usually in the order of Mega Hertz.
Instruction throughput is given higher priority than interrupt latency.	In contrast, microcontrollers are designed to optimize interrupt latency.
Have few bit manipulation instructions	Bit manipulation is powerful and widely used feature in microcontrollers. They have numerous bit manipulation instructions.
Generally microprocessors are not used in real time systems as they are severely dependent on several other components.	Microcontrollers are used to handle real time tasks as they are single programmed, self sufficient and task oriented devices.

1. Think about some computational scenario and sort these computational needs according to which should be used? Microprocessor or microcontroller.
2. What is the difference between microprocessor and microcontroller?

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Classification of microprocessor

A microprocessor can be classified into three categories –

1. RISC Processor
2. CISC Processor
3. Special Processor

RISC Processor

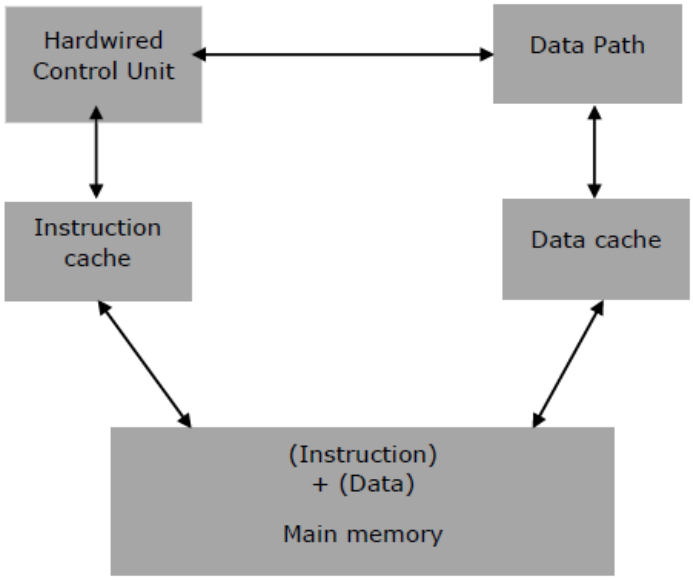
RISC stands for **Reduced Instruction Set Computer**. It is designed to reduce the execution time by simplifying the instruction set of the computer. Using RISC processors, each instruction requires only one clock cycle to execute results in uniform execution time. This reduces the efficiency as there are more lines of code, hence more RAM is needed to store the instructions. The compiler also has to work more to convert high-level language instructions into machine code.

Some of the RISC processors are –

- Power PC: 601, 604, 615, 620
- DEC Alpha: 210642, 211066, 21068, 21164
- MIPS: TS (R10000) RISC Processor
- PA-RISC: HP 7100LC

Architecture of RISC

RISC microprocessor architecture uses highly-optimized set of instructions. It is used in portable devices like Apple iPod due to its power efficiency.



Characteristics of RISC

The major characteristics of a RISC processor are as follows –

- It consists of simple instructions.
- It supports various data-type formats.
- It utilizes simple addressing modes and fixed length instructions for pipelining.
- It supports register to use in any context.
- One cycle execution time.
- "LOAD" and "STORE" instructions are used to access the memory location.
- It consists of larger number of registers.
- It consists of less number of transistors.

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CISC Processor

CISC stands for **Complex Instruction Set Computer**. It is designed to minimize the number of instructions per program, ignoring the number of cycles per instruction. The emphasis is on building complex instructions directly into the hardware.

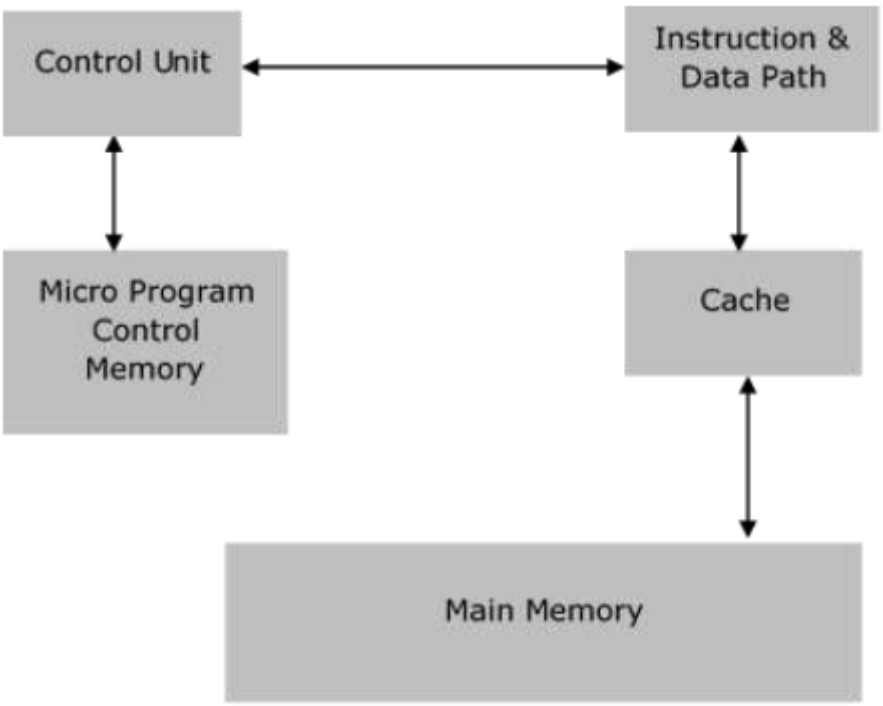
The compiler has to do very little work to translate a high-level language into assembly level language/machine code because the length of the code is relatively short, so very little RAM is required to store the instructions.

Some of the CISC Processors are −

- IBM 370/168
- VAX 11/780
- Intel 80486

Architecture of CISC

Its architecture is designed to decrease the memory cost because more storage is needed in larger programs resulting in higher memory cost. To resolve this, the number of instructions per program can be reduced by embedding the number of operations in a single instruction.



Characteristics of CISC

- Variety of addressing modes.
- Larger number of instructions.
- Variable length of instruction formats.
- Several cycles may be required to execute one instruction.
- Instruction-decoding logic is complex.
- One instruction is required to support multiple addressing modes.

Special Processor

A **Digital Signal Processor** is a special-purpose CPU (Central Processing Unit) that provides ultra-fast instruction sequences, such as shift and add, and multiply and add, which are commonly used in math-intensive signal processing applications. A digital signal processor (DSP) is a specialized microprocessor designed specifically for digital signal processing, generally in real time.

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A DSP contains the following components −

- Program Memory − It stores the programs that DSP will use to process data.
- Data Memory − It stores the information to be processed.
- Compute Engine − It performs the mathematical processing, accessing the program from the program memory and the data from the data memory.
- Input/Output − It connects to the outside world.

A **coprocessor** is a specially designed microprocessor, which can handle its particular function many times faster than the ordinary microprocessor. For example − Math Coprocessor.

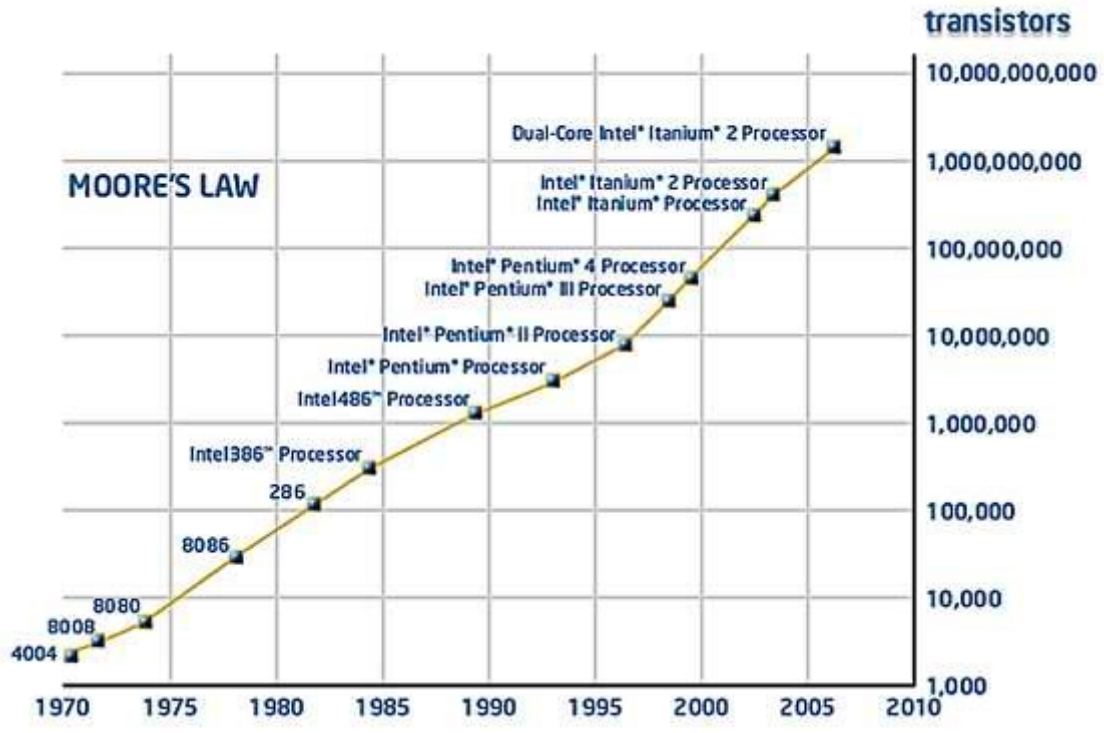
Input/Output Processor is a specially designed microprocessor having a local memory of its own, which is used to control I/O devices with minimum CPU involvement.

For example −

- DMA (direct Memory Access) controller
- Keyboard/mouse controller
- Graphic display controller
- SCSI port controller

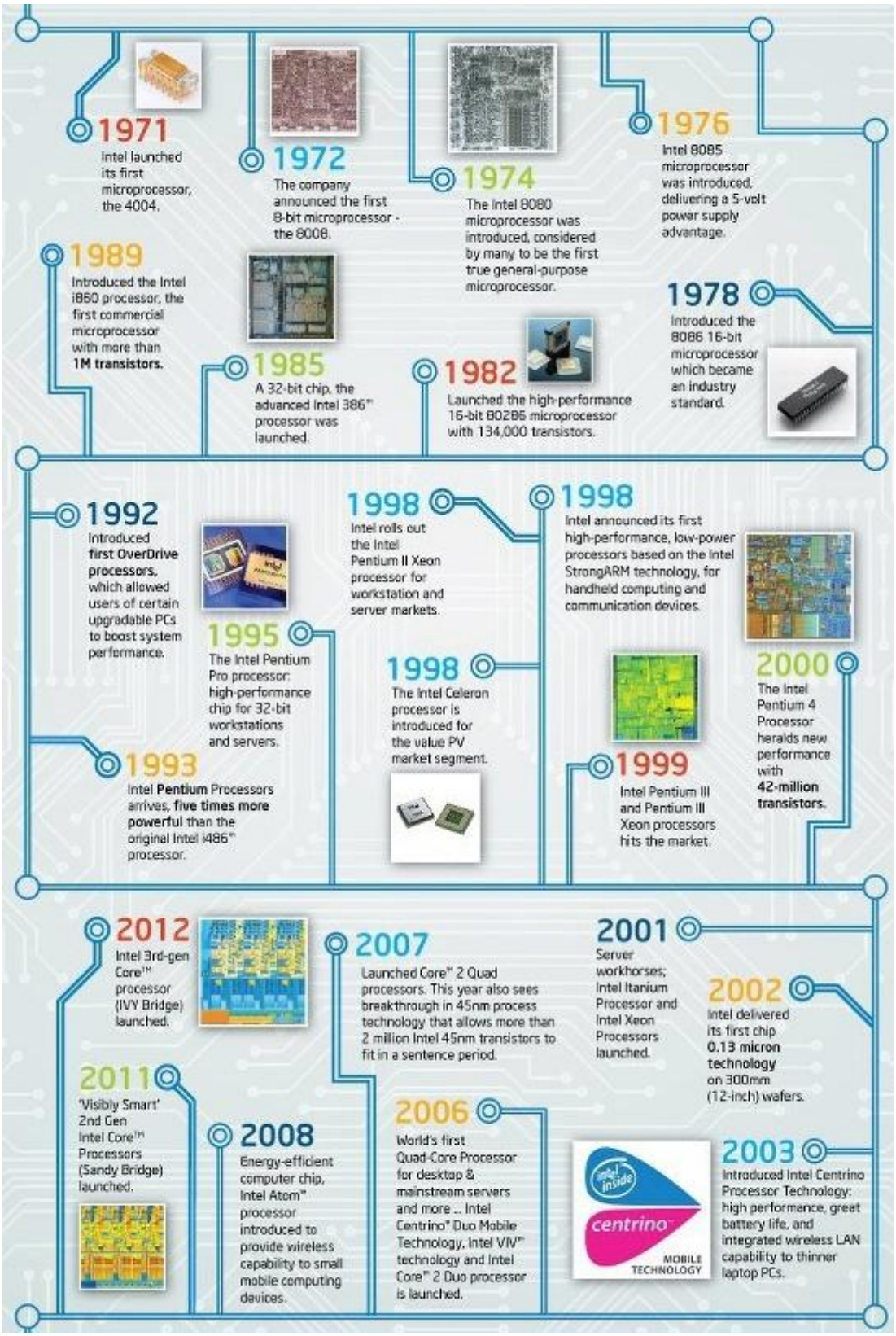
Moore's Law

Moore's law is the observation that the number of transistors in a dense integrated circuit doubles approximately every two years. The observation is named after Gordon Moore, the co-founder of Fairchild Semiconductor and Intel, whose 1965 paper described a doubling every year in the number of components per integrated circuit, and projected this rate of growth, would continue for at least another decade. In 1975, looking forward to the next decade, he revised the forecast to doubling every two years. The period is often quoted as 18 months because of Intel executive David House, who predicted that chip performance would double every 18 months (being a combination of the effect of more transistors and the transistors being faster).



Evolution of Microprocessor

The info graphic below shows the evolution of Intel microprocessor.



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The table below shows some of the important at a glance information for intel microprocessors over its evolution period.

Name	*Date*	*Transistors used*	*Max Clock Speed*	*Address Lines*	*Data width*	*MIPS*	*Max addressable memory*
4004	1971	2K	740 KHz	12-bit	4-bit		4KB, no cache
8008	1972	3.5K	200-800 KHz	14-bit	8-bit		16KB, no cache
8080	1974	6 k	2 MHz	16-bit	8-bit	0.64	64KB, no cache
8086	1978	29 K	8 MHz	20-bit	16-bit	0.8	1MB, no cache
8088	1979	29 K	5 MHz	20-bit	8-bit bus	0.33	1MB, no cache
80286	1982	134 K	12.5 MHz	24-bit	16-bit	2.7	16MB, no cache
80386	1985	275 K	20 MHz	32-bit	32-bit	6	4GB, no cache
80486	1989	1.2 M	25 MHz	32-bit	32-bit	20	4GB, 8K level 1
Pentium	1993	3.1M	100 MHz	32-bit	64-bit/32-bit	100	4GB, 16K level 1
Pentium Pro	1995	5.5M	440 MHz	32-bit	64-bit/32-bit	440	64GB, 16K level 1
Pentium II	1997	7.5M	266 MHz	32-bit	64-bit/32-bit	446	64GB, 32K level 1
Pentium III	1999	9.5M	500 MHz	32-bit	64-bit/32-bit	1000	64GB, 32K level 1
Pentium 4	2000	42M	1.5 GHz	32-bit	64-bit/32-bit	1700	64GB, 32K level 1
Pentium 4 Prescott	2004	125M	3.6 GHz	32-bit	64-bit/32-bit	7000	64GB, 32K level 1

Although there are many other microprocessor architecture like ARM, AVR, etc manufactured by several chip manufacturer like Qualcomm, Mediatek, Microchip etc, in this course we will mainly focus on the Intel side of the microprocessor family for simplicity. To be more specific this course will cover mainly 8085, 8096 and similar microprocessors.

3. Explain Moore's Law.
4. What are the differences between CISC and RISC processor?

Reference books

1. Microprocessors and interfacing by Douglas V hall
2. Microprocessors, PC Hardware and interfacing by N. Mathivanan
3. Assembly Language Programming and Organization for the IBM PC by Ytha Yu and Charles Marut [For Lab]