Microcomputer Technology

Chapter 1: Basic Microcomputer Concepts

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Chapter 1: Basic Microcomputer Concepts

- Aims
  - Describe the main terminologies, internal architecture and operating principles of microcomputer and its components.
- Expected Outcomes
  - To identify and explain typical terminology used in microcomputer technology.
  - To distinguish the applications of microprocessor, microcomputer and microcontroller.
  - To demonstrate the internal architecture of microcomputer components.
- References
  - Fernando E. Valdes-Peres, Ramon Pallas-Aremy, Microcontroller: Fundamental and Applications.

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Content Chapter 1

- Microprocessor, microcomputer and microcontroller
- Microcomputer components
- Microcomputer architecture

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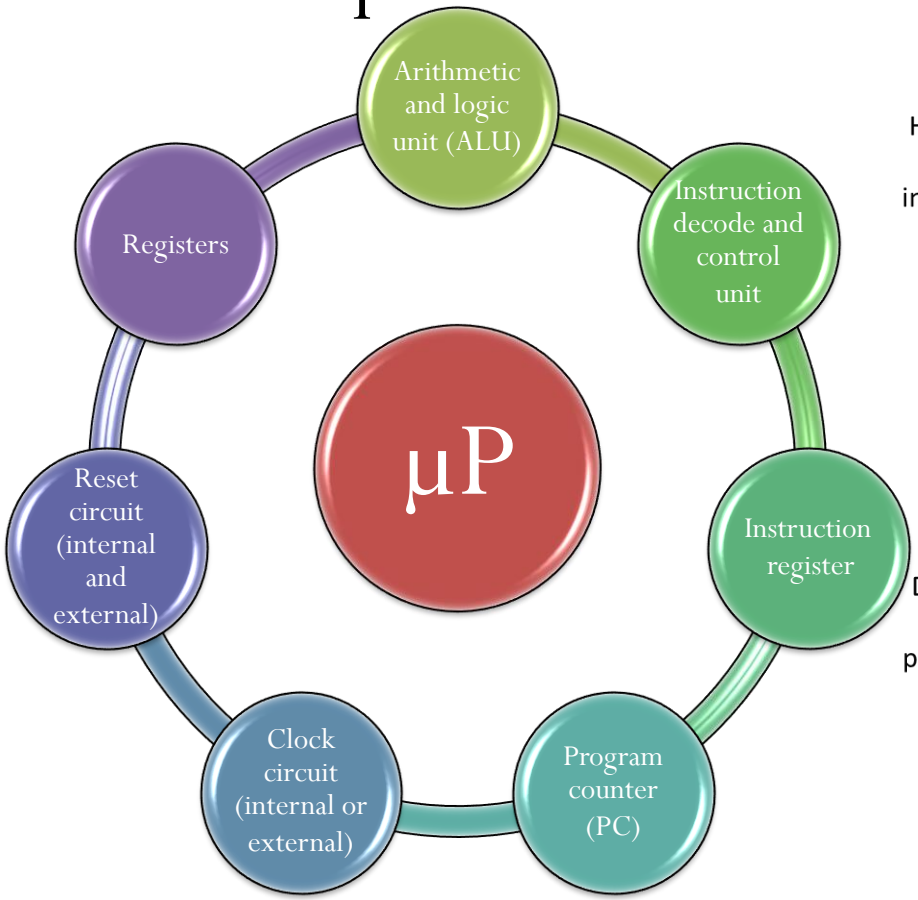
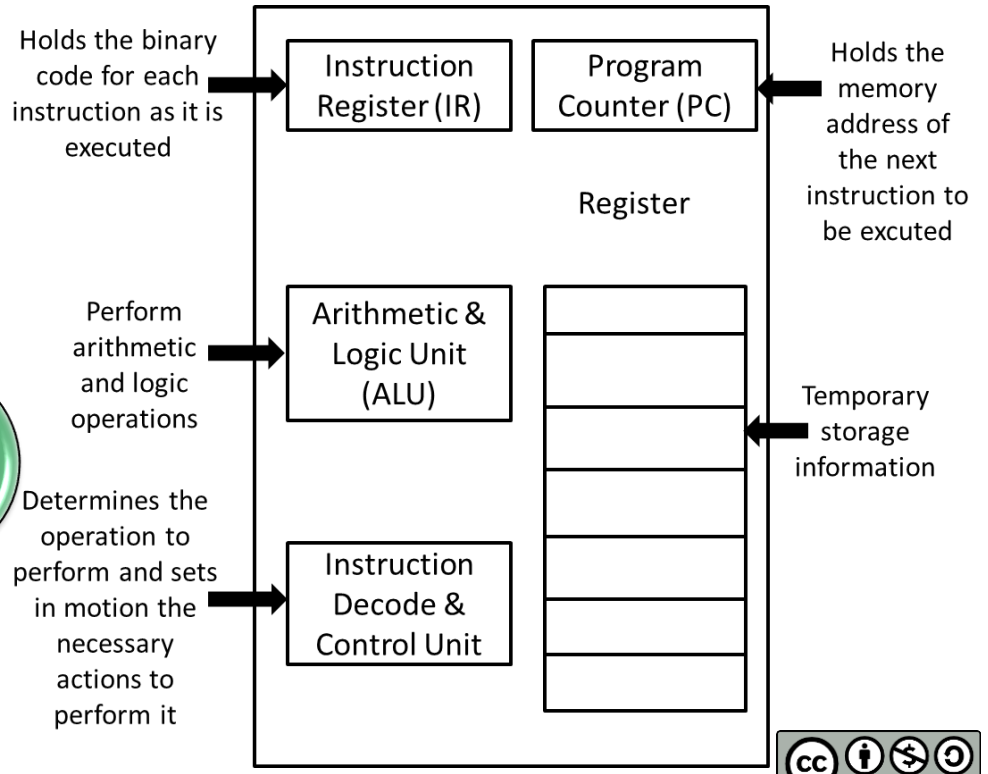
Microprocessor

- Microprocessor: a CPU built into a single chip.





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COMMON MICROPROCESSOR

No.	µP Type	Founded	No. of Transistors	Clock Speed	Data Width
1	8080	1974	6000	2MHZ	8 bits
2	8088	1979	29 000	5MHZ	16 bits 8-bit bus
3	80286	1982	134 000	6MHZ	16 bits
4	80386	1985	275000	16MHZ	32 bits
5	80486	1989	1 200 000	25MHZ	
6	Pentium I	1993	3 100 000	60MHZ	32 bits 64- bit bus
7	Pentium II	1997	7 500 000	233MHZ	
8	Pentium III	1999	9 500 000	450MHZ	
9	Pentium 4	2000	42 000 000	1.5 GHZ	
10	Pentium 4 “Prescott”	2004	125 000 000	3.6 GHZ	

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TERMINOLOGY

Input Device

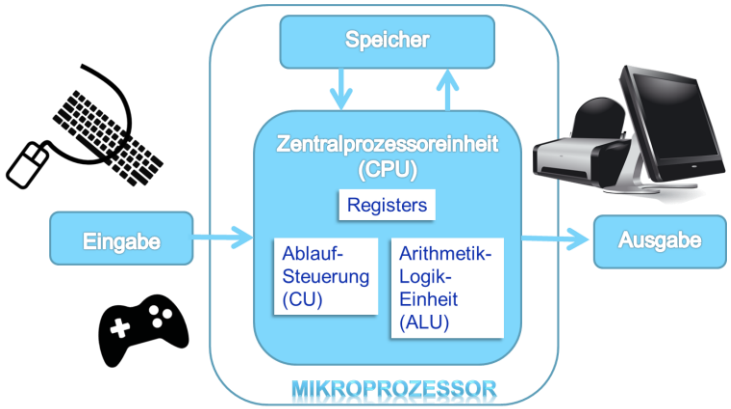
- Reads information from input media and enters to the computer in a coded form

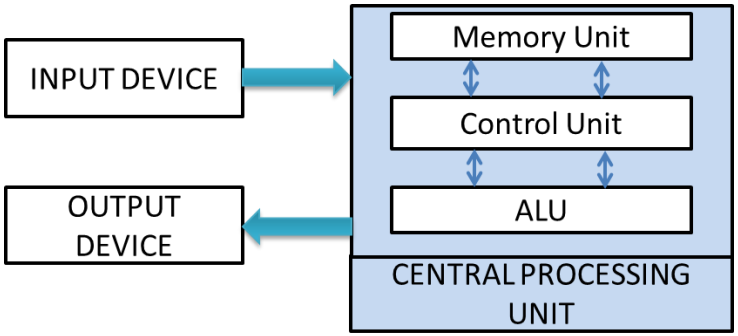
CPU

- Memory unit : Stores program and data
- Arithmetic Logic unit : Performs arithmetic and logical function
- Control Unit : Interprets program instructions and controls the input and output devices

Output device

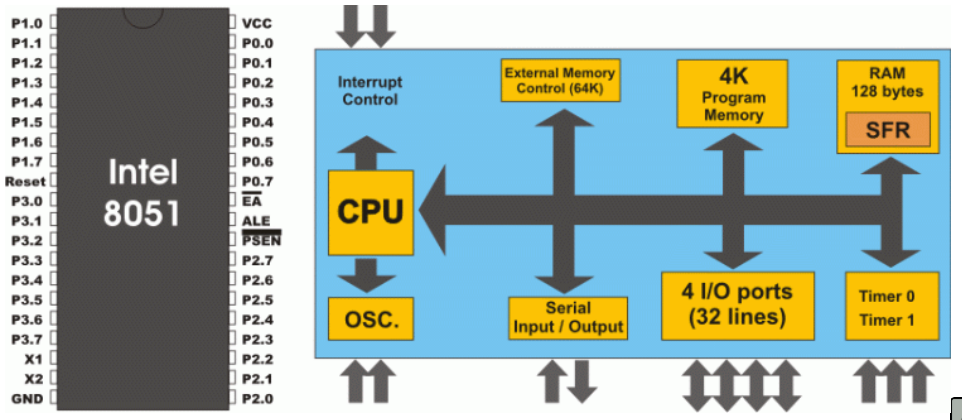
- Decodes information and presents it to the user





Microcontroller

- Highly integrated chip, which includes on single chip, all or most of the parts needed for a controller
- Commonly it includes:
  - ✓ Central Processing Unit (CPU)
  - ✓ Random Access Memory (RAM)
  - ✓ EPROM/PROM/ROM (Erasable Programmable Read Only Memory)
  - ✓ Input/output (I/O)- serial and parallel
  - ✓ Timers
  - ✓ Interrupt controller
  - ✓ It typically includes



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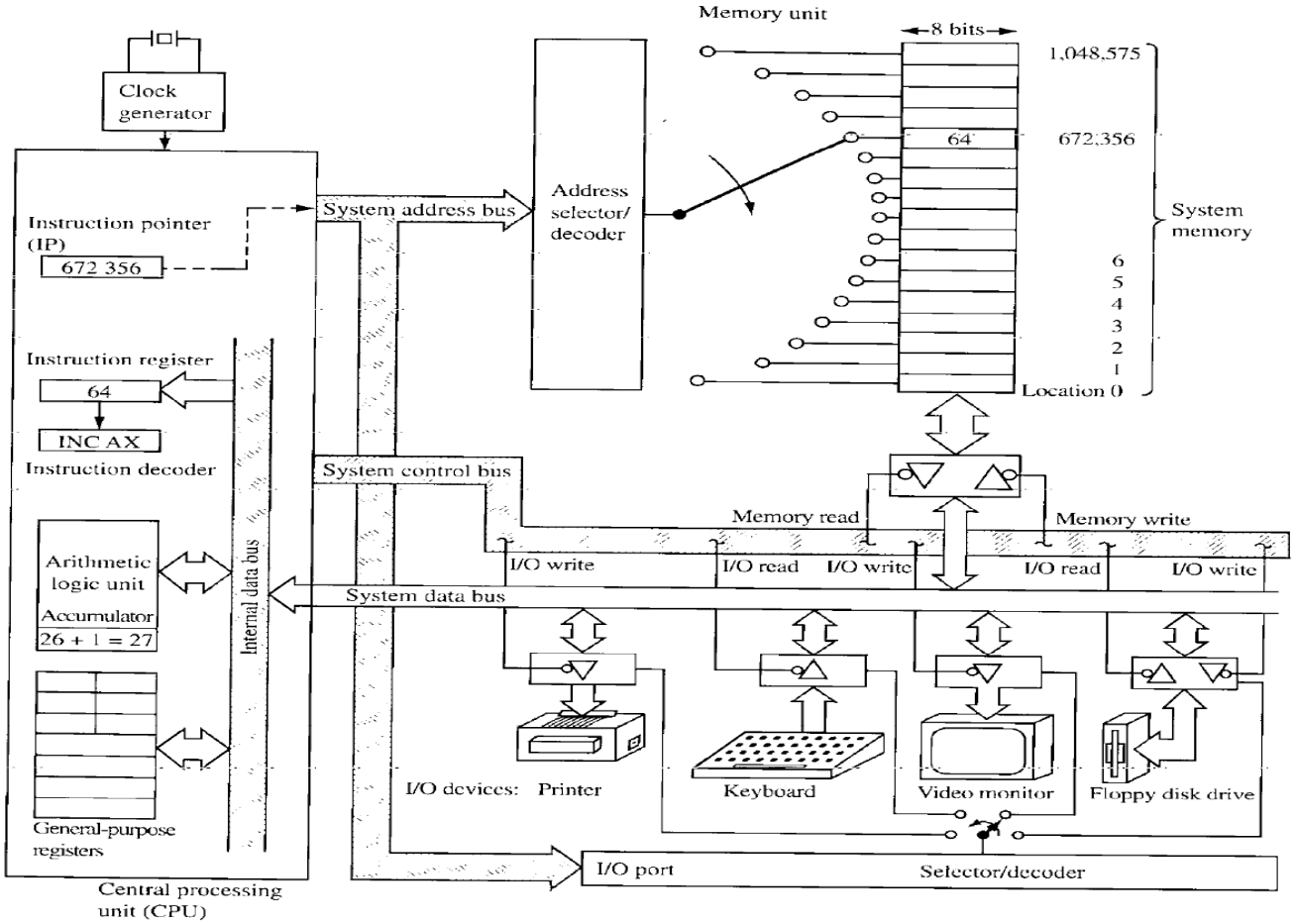
Example: Microprocessor 8085



Different µ-processor and µ-controller

Microcontroller (MCU)

- Including RAM, ROM, serial and parallel interface, timer, interrupt schedule circuitry (in addition to CPU) in single chip
  - Interrupt system is an important features, as microcontrollers have to respond to control oriented devices in real time. E.g.: opening microwave oven's door cause an interrupt to stop the operatio
- MCU used in small, minimum component designs performing control-oriented activities
- MCU have instruction sets catering to control of inputs and outputs. Their instructions operate also on a single bits. Eg., a motor may be turned ON and OFF by a 1-bit output port

Microprocessor (µP)

- Single chip CPU, microcontroller contains, a CPU and much of the remaining circuitry of a complete microcomputer system in a single chip.
- Commonly used as the CPU in microcomputer systems.
- µP instruction sets are processing intensive, implying powerful addressing modes with instruction catering to large volumes of data. Their instructions operate on nibbles, bytes etc.

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CPU

The brain of the computer system, administers all activity in the system and performs all operations on data. It continuously performs two operations: fetching and executing instructions. It understand and execute instructions based on a set of binary codes called the instruction set.

To execute an instruction–the processor must:

- Fetch the instruction from memory
- Decode the instruction
- Execute the instruction
- Store the result back in the memory.

} Memory cycle

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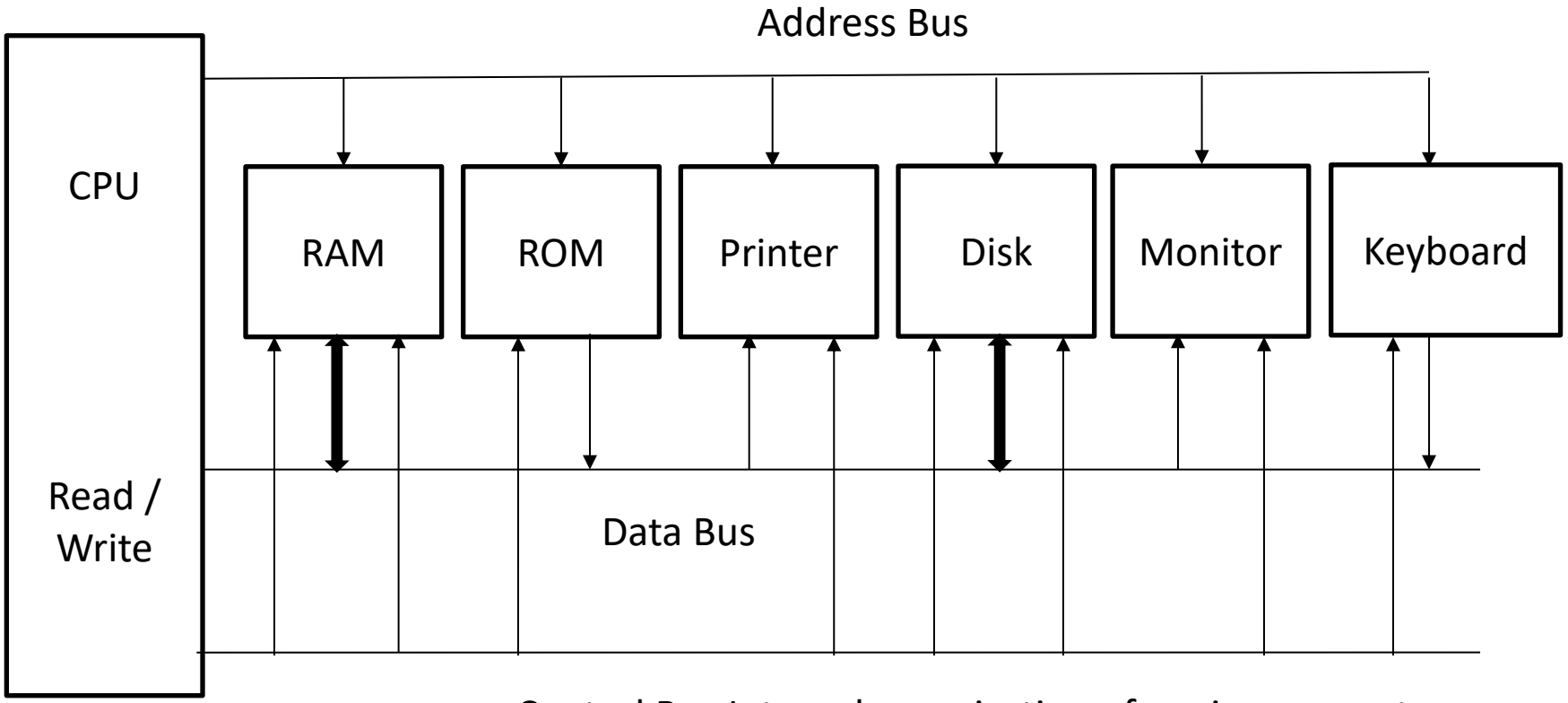
Communication



Internal organisation of a microcomputer

- Addressing range: An 8-bit address bus would be able to specify only 256 addresses

Processor

- ✓ Series of registers (index registers, instruction registers, process status registers)
- ✓ Some electronic circuitry to perform arithmetic and logical operations on the contents of registers
- ✓ Some circuitry to decode and execute sequence of instructions
- ✓ Buffers to interface the signal within the processor of the real world (address and data bus)
- ✓ A series of buses that join the various components together

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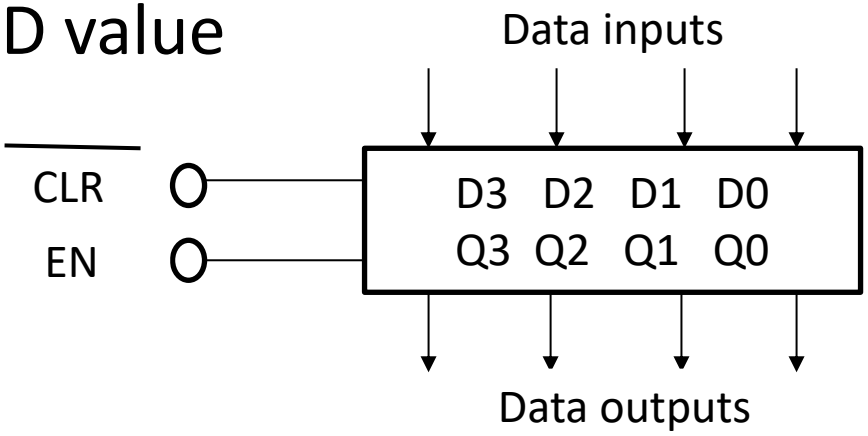
Registers

- The register is a fundamental building block within a computer system (e.g. the memory section of the computer consists of a large number of registers that can be used to store both data and programs.)
- D-flip flop :when EN is high, the outputs follow the inputs, when EN goes low the outputs latch and hold the last D value



THE BUSES: ADDRESS, DATA, AND CONTROL

- ADDRESS BUS carries the address of a specified location. For n address lines, 2 locations can be accessed. E.g., A 16-bit address bus can access 216 = 65,536 locations or 64K locations (210 = 1024 = 1K, 26 = 64).
- DATA BUS carries information between the CPU and memory or between the CPU and I/O devices.
- CONTROL BUS carries control signals supplied by the CPU to synchronize the movement of information on the address and data bus.

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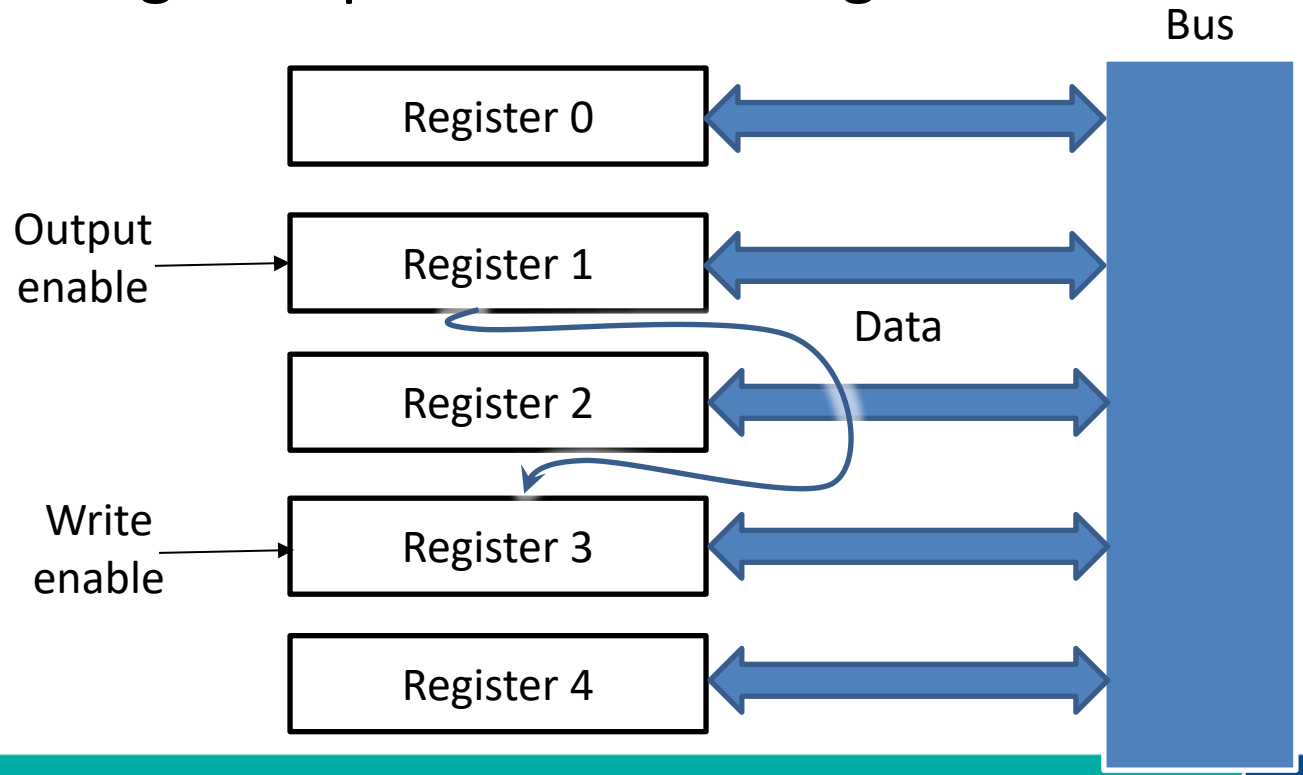
Data Busing

- Reading: The process of taking information from register and placing it on the bus.
- Writing: The process of storing information in a register



Register-Bus Communication

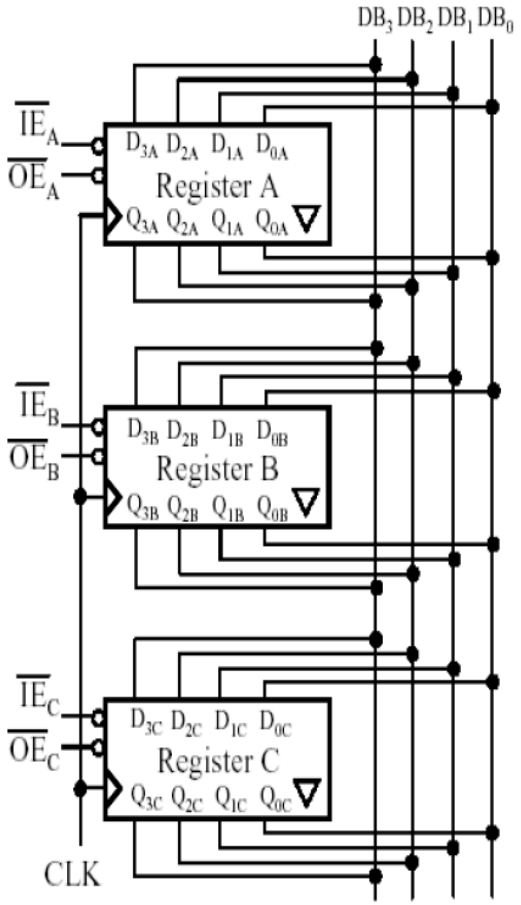
- The contents of any register can be parallel-transferred over the bus to any of the others
- E.g to transfer [A] → [C]:
- Only register A should have enabled outputs so,

$$\overline{OE}_A=0 \;\&\; \overline{OE}_B=\overline{OE}_C=1$$

- This will cause the contents of A to appear on the data bus lines
- Next only C should have its inputs enabled so

$$\overline{IE}_C=0,\; \overline{IE}_A=\overline{IE}_B=1$$

- On the next rising clock edge C will latch the data from the bus



Data and program storage

- Number system: Decimal, binary, hexadecimal
- Negative number representation
- $101_2 = 5_{10}$ (positive) . .
- $0101_2 = 5_{10}$ (positive)
- . | . Extra bit, representing sign (0=positive, 1=negative). .
- 1011_2 = -510(negative)
- . | . Extra bit, representing sign (0=positive, 1=negative)
- 8-bit representation: 00000011 = 3 and -3 is ?
- What is the range of 16 bit signed quantity?

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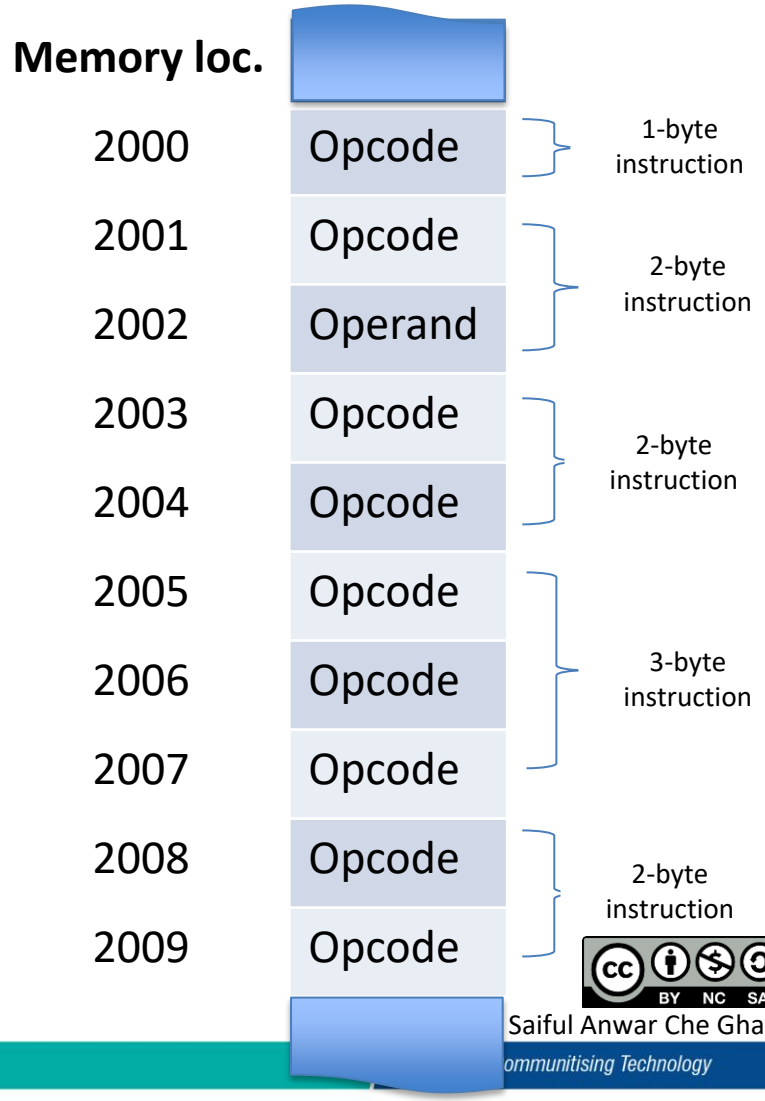
Program

- A computer program is a list of instructions to the processor.
- Instructions for transferring data between registers, transferring data between registers and memory, performing various arithmetic and logical operations, comparisons and test on register contents and controlling the sequence of program execution



FETCHING AND EXECUTING AN INSTRUCTION

- Fetching involves the following steps:
  - Contents of PC are placed on address bus.
  - READ signal is activated.
  - Data (instruction opcode) are read from RAM and placed on data bus.
  - Opcode is latched into the CPU's internal instruction register.
  - PC is incremented to prepare for the next fetch from memory.
- While execution involves decoding the opcode and generating control to gate internal registers in and out of the ALU and to signal the ALU to perform the specified operation.

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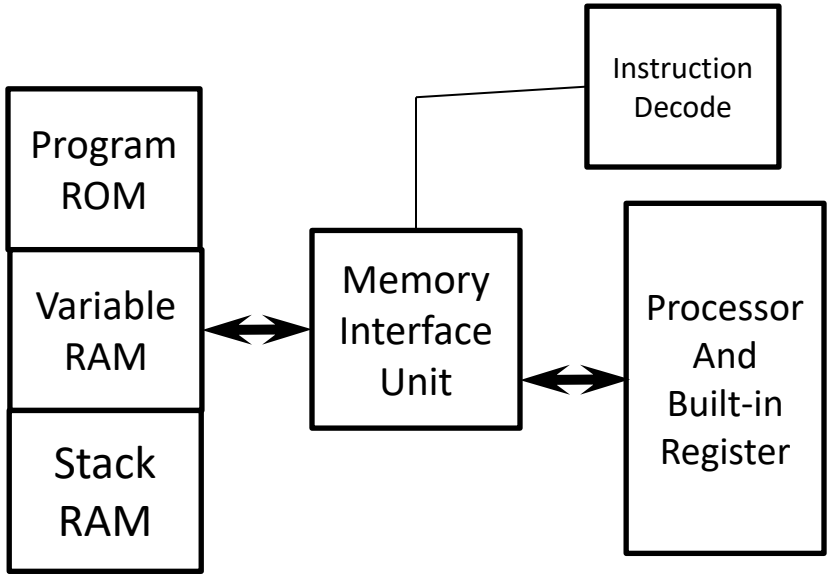
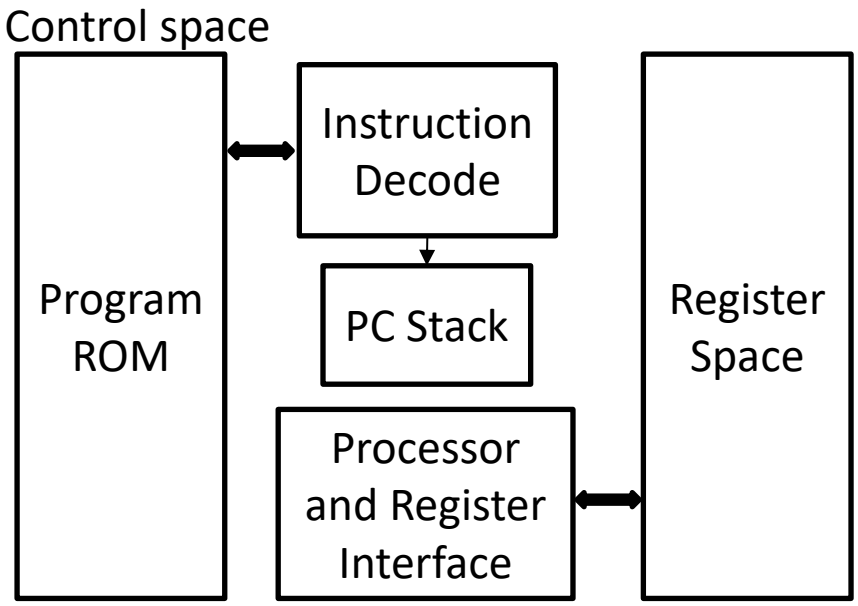
Architecture





- Example : An Instruction "Read a byte from memory and store it in the accumulator" as follows:
  - Cycle 1 :- Read instruction
  - Cycle 2 - Read data out of RAM and put into Accumulator

- The same instruction would be executed as follows:
  - Cycle 1: - Complete previous instruction – Read the "Move Data to Accumulator" instruction
- Cycle 2: - Execute "Move Data to Accumulator" instruction - Read next instruction

Memory

- Modern Integrated Circuits may consists multi millions of memory registers.
- A device with 1024 8-bit memory would be called a 1kbyte memory and would have 10 address lines while a device with 4096 memory would be 4kbyte with 12 address lines
- Two of the controls are output enable and write enable which are invariably low hence $\overline{OE}$ and WE
- Types:
  - Random Access Memory
  - Read Only Memory

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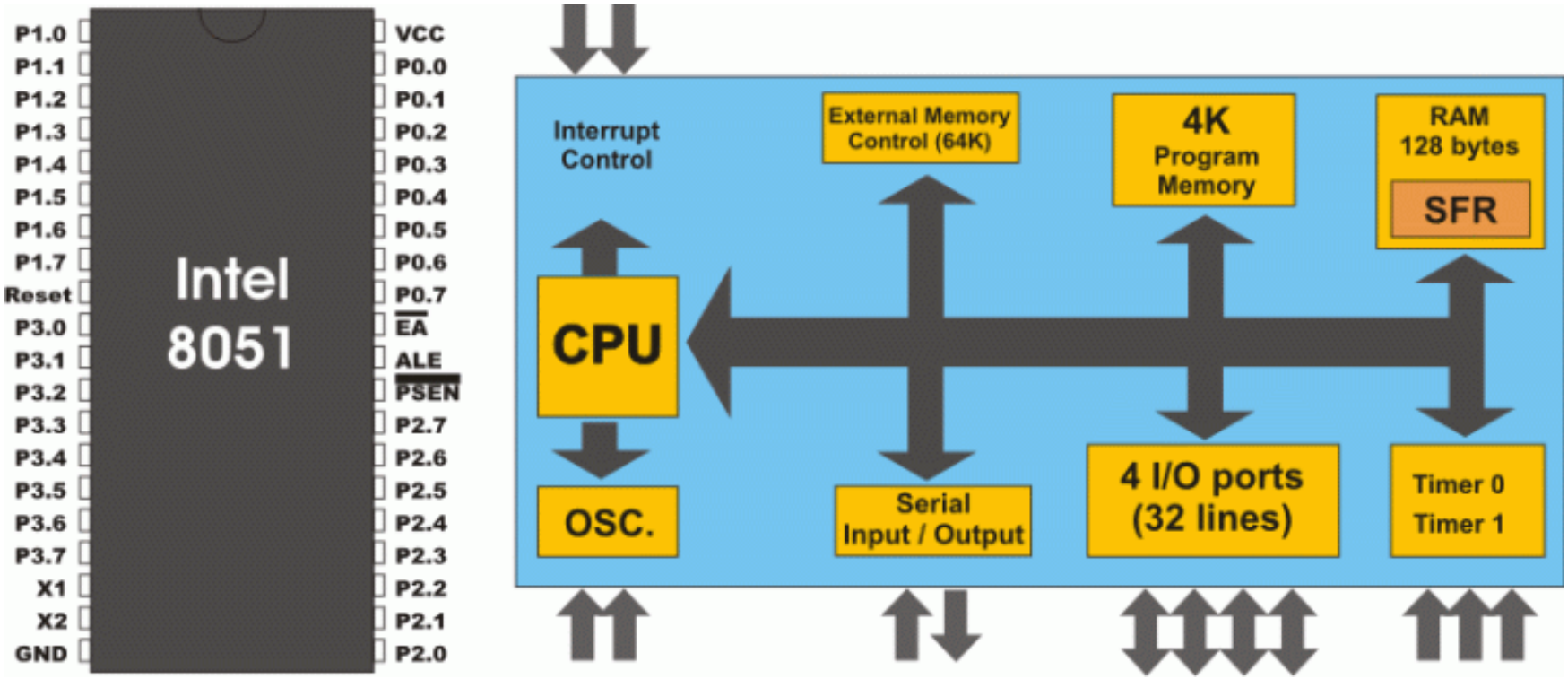
Architecture Intel 8051



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Conclusion of The Chapter

- Common terminology
  - BIT (**B**inary Dig**it**): Basic unit of digital storage; 0 or 1
  - CPU: The brains of a computer (Central Processing Unit)
  - Memory: RAM or ROM, digital circuitry to store programs or data
  - I/O: generic term describing how info enters or exit a computer.
- µP, µC, MCU
  - Microprocessor (µP or MPU): Complex logic IC that contains registers, counters and decoders and performs arithmetic, logic & control operations, a CPU on a single LSI chip.
  - Microcomputer (µC): a fully functional system incl. a MPU, memory, I/O, and a clock
  - Microcontroller (MCU): a microcomputer on a single chip
- Computer Architecture
  - Interconnection of CPU + Memory + I/O by buses and driven by a clock system.

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