Microcomputer Systems

Outline

- Components of microcomputer system
- Executing an instruction
- I/O devices
- Programming languages

Components of a Microcomputer System

- Memory
  - Information processed by the computer is stored in its memory.
- The CPU
  - In a microcomputer the CPU is a single chip processor known as microprocessor.
- I/O Ports
  - System board or mother board contains expansion slots which are connectors for additional circuits boards called add in boards. I/O circuits are usually on these boards.

Memory

- A memory circuit element can store one bit of data.
- Organized into groups that can store eight bits of data.
- String of eight bits called a byte.
- Each memory byte is identified by address.
- The first memory byte has address 0.
- The data stored in a memory byte called its contents or values.
- The address of a memory byte is fixed and different from any other addresses whereas contents are not fixed.
- The contents of memory byte are always eight bits but address depends on the processor. For example some assign 20 bits address whereas some assign 24 bit address.

Memory

- Bit Position
  - The positions are numbered from right to left starting with 0.
  - Low byte comes from memory byte with lower address and high byte comes from memory byte with higher address.

Byte	7	6	5	4	3	2	1	0

Word	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0

- Operations
  - Processor can perform two operations on memory: read(fetch) and write(store).
  - In read processor gets a copy of data and the contents of that location is unchanged whereas in write the data becomes the new content of the location.

Memory

- RAM and ROM
  - Two kinds of memory circuits: RAM(Random Access Memory) and ROM(Read Only Memory).
  - RAM locations can be read and write but ROM locations only can be read.
  - Program instructions and data normally loaded into RAM.
  - System programs are stored in ROM.
  - RAM memory lost when the power is off but ROM circuits retain their values when the power is off.
- Buses
  - Processor communicates with memory and I/O devices by using signals that travel along a set of wires called buses.
  - Three kinds of buses: address bus, data bus and control bus.

Memory Devices

- Random-Access Memory (RAM)
  - DRAM = Dynamic RAM
    - 1-Transistor cell + trench capacitor.
    - Dense but slow, must be refreshed.
    - Typical choice for main memory.
  - SRAM: Static RAM
    - 6-Transistor cell, faster but less dense than DRAM.
    - Typical choice for cache memory.
- Read-Only-Memory(ROM)
  - Many types: ROM, EPROM, EEPROM, and FLASH memory can be erased electrically in blocks.
- Cache
  - A very fast type of RAM that is used to store information that is most frequently or recently used by the computer.
  - Recent computers have 2-levels of cache; the first level is faster but smaller in size (usually called internal cache), and the second level is slower but larger in size (external cache).

Memory

- Suppose a processor uses 20 bits for an address. How many memory bytes can be accessed?
- The number of memory bytes will be $2^{20} = 1{,}048{,}576 = 1\text{MB}$

CPU

- It controls computer by executing programs stored in the memory.
- The instructions performed by a CPU is known as instruction set.
- Instruction set for each CPU is unique.
- 8086 microprocessor has two main components: Execution Unit and Bus Interface Unit.
- EU and BIU is connected by an internal bus.
- When EU is executing an instruction the BIU fetches up to six bytes of the next instruction and places them in the instruction queue known as instruction pre-fetch.

CPU

- Execution Unit
  - Used to execute instructions.
  - Contains a circuit called Arithmetic and Logic Unit(ALU).
  - The data for the operations are stored in circuits called registers.
  - Eight registers for storing data: AX, BX, CX, DX, SI, DI, BP and SP.
  - It also contains FLAGS register whose individual bits reflect the result of a computation.
- Bus Interface Unit
  - Facilitates communication between the EU and the memory or I/O circuits.
  - Transmits addresses, data and control signals on the buses.
  - Registers are CS, DS, ES, SS and IP holding address of memory locations.
  - IP contains the address of the next instruction to be executed by the EU.

I/O Ports

- I/O devices are connected to the computer through I/O circuits.
- Each of these circuits contains several registers known as I/O ports.
- I/O ports have addresses and connected to the bus system.
- These addresses are known as I/O addresses and can only be used in input or output instructions.
- Data to be input from an I/O device are sent to a port where they can be read by the CPU.
- On output CPU writes data to an I/O port.
- Two types of I/O ports: Serial and Parallel.

I/O Ports

- Serial port
  - Transfers one bit at a time.
  - Used for slower transfer such as keyboard.
- Parallel port
  - Transfers 8 or 16 bits at a time.
  - Requires more wiring connections.
  - Used for faster data transfer such as disk drives.

I/O Devices

- Magnetic Disk
  - Magnetic disks are used for permanent storage of programs and data.
  - The device that reads and writes data on a disk is called disk drive.
  - Floppy Disk
    - Light weight and portable.
    - Easy to put away for safekeeping and use it on different computers.
    - Amount of data depends on type, ranging from 360KB-1.44MB (1KB).
  - Hard Disk
    - Enclosed in a hermetically sealed container that is non removable from computer called a fixed disk.
    - Can store more data than floppy disk. Typically 20, 40 to over 100MB.
    - A program can access information in a hard disk much faster than a floppy disk.

I/O Devices

- Keyboard
  - Allows the user to enter information in a computer.
  - It has keys of typewriters and a number of control and function keys.
  - Has own microprocessor that sends coded signal to computer when a key is pressed or released.
  - No direct contact between keyboard and display.
- Display Monitor
  - Standard output device of the computer.
  - Displayed information on the screen is generated by video adapter.
  - Most adapters can generate both text characters and graphics images.
  - Some even display in color.

I/O Devices

- Printers
  - Printers are slower than monitors but provide more permanent output.
  - Printer outputs are known as hardcopies.
  - Daisy wheel
    - The output is similar to that of a typewriter.
  - Dot matrix
    - Prints characters composed of dots.
    - Some can generate near-letter-quality printing.
    - Print characters with different fonts as well as graphics.
  - Laser printers
    - Print characters composed of dots.
    - The resolution is high (300 dots per inch).
    - It is expensive.

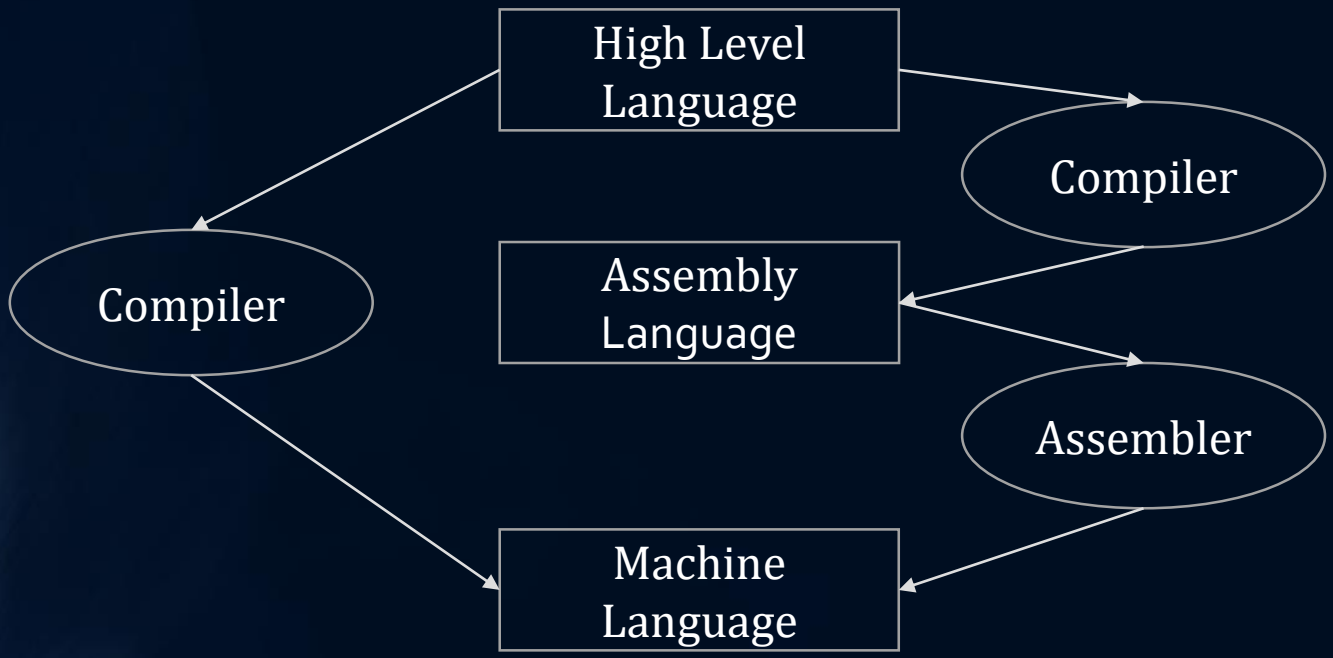
Instruction Execution

- Machine instructions have two parts: Opcode and Operands.
- Opcode field which stands for operation code and it specifies the particular operation that is to be performed. Each operation has its unique opcode.
- Operands fields which specify where to get the source and destination operands for the operation specified by the opcode. The source/destination of operands can be a constant, the memory or one of the general-purpose registers.
- The steps of executing an instruction(the fetch-execution cycle) are:
  - Fetch
    1. Fetch an instruction from memory.
    2. Decode the instruction to determine the operation.
    3. Fetch data from memory if necessary.
  - Execution
    1. Perform the operation on the data.
    2. Store the result in memory if needed.

Programming Languages

- Machine language
  - A CPU can only execute machine language instructions.
  - Instructions consist of binary code: 1s and 0s.
- Assembly language
  - A programming language that uses symbolic names to represent operations, registers and memory locations.
  - Readability of instructions is better than machine language.
  - One-to-one correspondence with machine language instructions to machine code.
  - Assemblers translates assembly code to machine code.
- High Level Language
  - Compilers translate high-level programs to machine code directly or indirectly via an assembler.

Compiler and Assembler



Advantages of High-Level Languages and Assembly Language

- High Level Language
  - Program development is faster as it is closer to natural language.
  - Program maintenance is easier.
  - Programs are portable as it can be used with little or no modifications on different machines.
- Assembly Language
  - Assembly Language is close to machine language.
  - It helps one to understand how the computer thinks.

Mapping Between Assembly Language and High Level Language

- Translating High Level Language programs to machine language programs is not a one-to-one mapping.
- A High Level Language instruction (usually called a statement) will be translated to one or more machine language instructions.

Instruction Class	C	Assembly Language
Data Movement	A=5	MOV A,5

Arithmetic or Logic	B=A+5	MOV AX,A
		ADD AX,5
		MOV B,AX

Data Movement	goto LBL	JMP LBL

Why Learn Assembly Language?

- Accessibility to system hardware
  - Assembly Language is useful for implementing system software.
  - Also useful for small embedded system applications.
- Space and Time efficiency
  - Understanding sources of program inefficiency.
  - Tuning program performance.
  - Writing compact code
- Writing assembly programs gives the computer designer the needed deep understanding of the instruction set and how to design one.
- To be able to write compilers for High Level Languages, we need to be expert with the machine language. Assembly programming provides this experience.