Chapter 1:
Introduction to Advanced Computer Architecture and Organization

- **Architecture & Organization**

Architecture : User view (function)

Organization : details of how it is made and interconnected?

Ex: user asks about : multiply instruction does it exists? architecture

How it is implemented ? Its cost , its size

Organization

Computer architecture :

describes the user's view of the computer. The instruction set types , visible registers, memory addressing techniques …etc

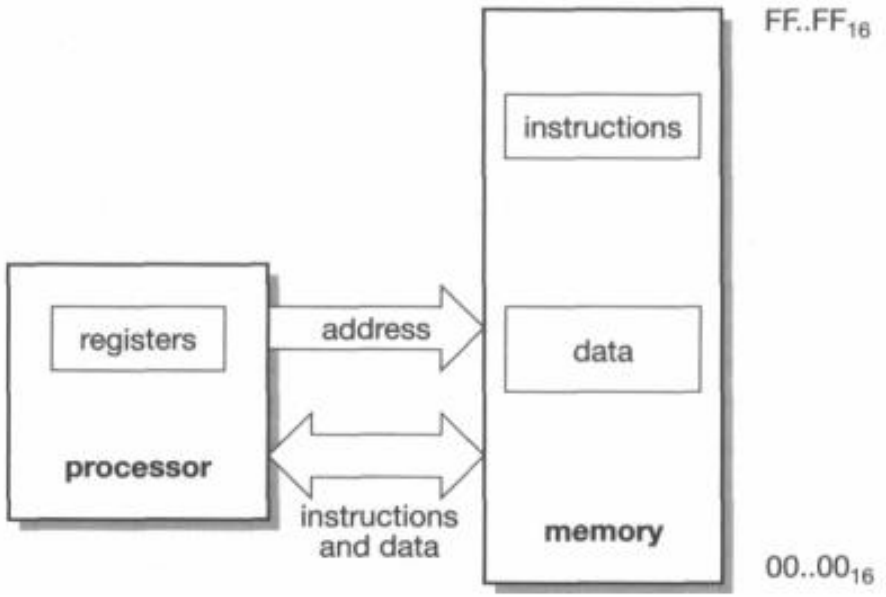
Computer organization :

describes the user-invisible implementation of the architecture.

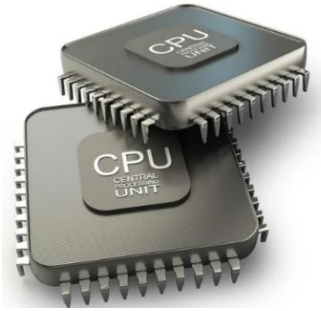
ALU design , control unit design ,…etc

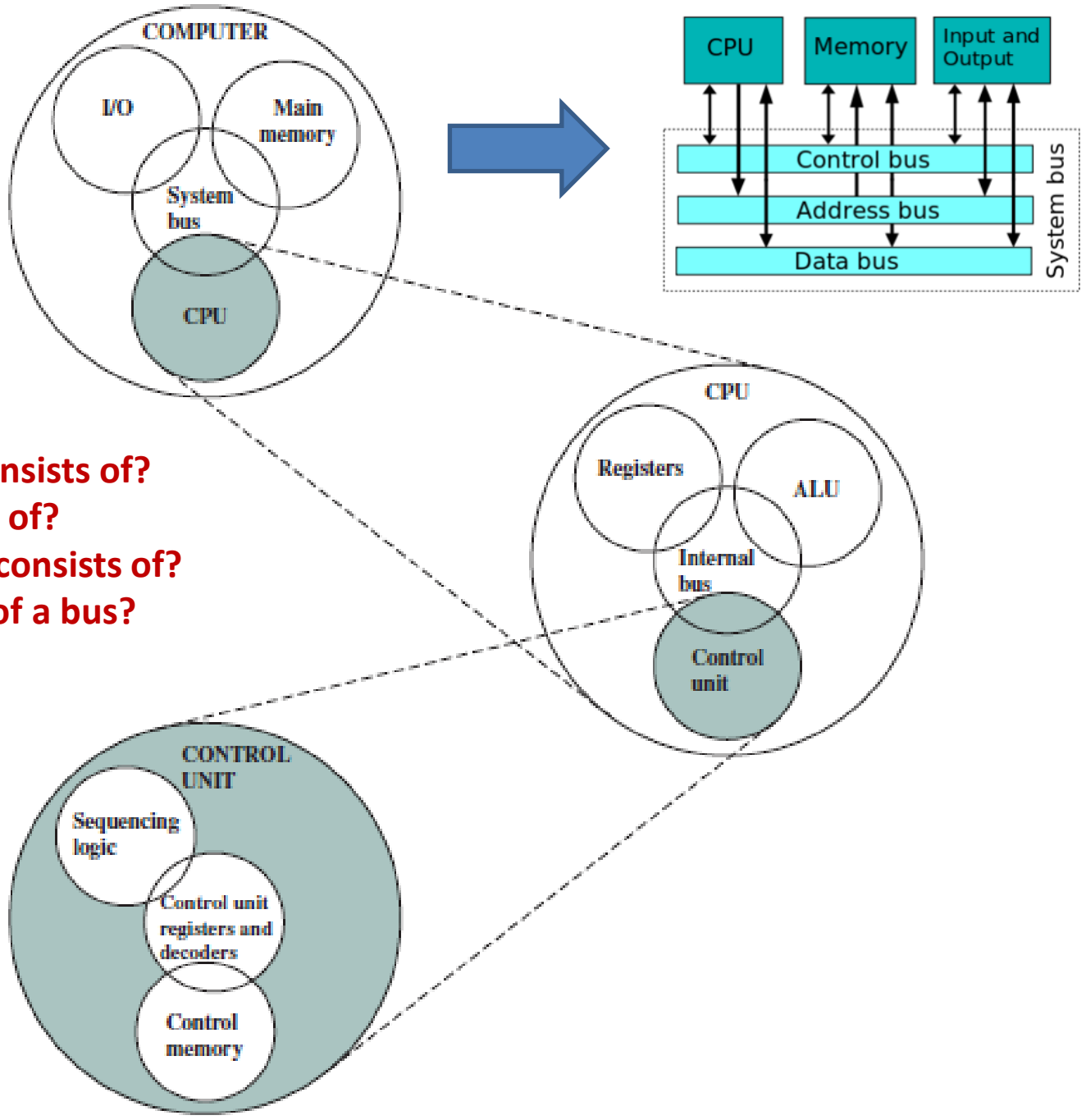
- **What Is a processor ?**
- **A stored-program concept (Von Neumann Architecture)**
- A complex logic system (logic gates, registers,…) that consists of millions of transistors on a chip - It executes program(instructions) held in a memory.
- **Applications:**
  - **desktop PC**
  - **Embedded:**

mobile, cars, ..



The state in a stored-program digital computer.



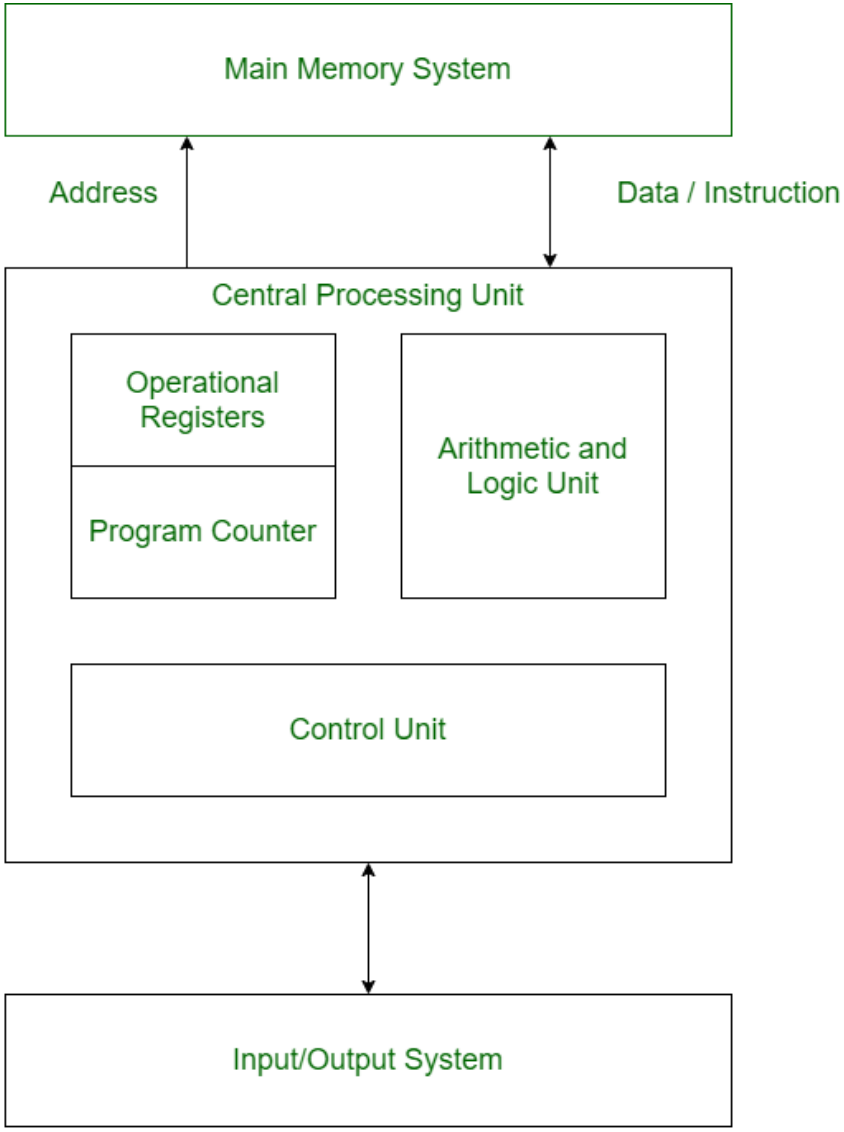


What a computer consists of?
What a CPU consists of?
What a control unit consists of?
What are the types of a bus?

Figure 1.1 The Computer: Top-Level Structure

Von Neumann processors(CICS) :opsolete ???

- Von-Neumann processors
  - Intel :80xxx, Pentium
  - Zilog :Z80
  - Rockwell :6502
  - Motorola :68xxx
- (CICS) Complex Instruction
- Set Computer

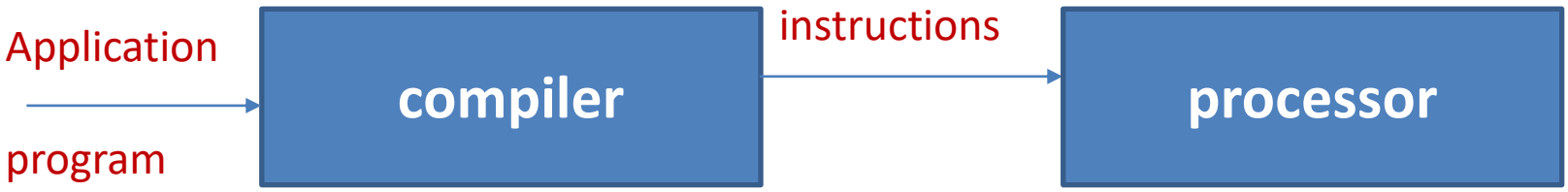


Is Von Neumann processor slow ?

- program →set of Instructions
- Instructions: data transfer , arithmatic & logic, branching…etc
- Statistics Example:Data movement instructions 43% → too much ????
- Others 57 % very low ??

- Solutions:
  - Pipelining
  - Caching
  - Harvard Archtecture

Instruction type	Dynamic usage
Data movement	43%
Control flow	23%
Arithmetic operations	15%
Comparisons	13%
Logical operations	5%
Other	1%



Example 1:

An application program consists of 1000 instructions.

40% of the instructions are data transfer instructions with 7 clock cycles each , 30 % are arithmatic instructions with 4 clock cycles each, 15% are logic instructions with 3 clock cycles each and the remaining instructions are branching instructions with 5 clock cycles each. If the processor uses 4 MHz clock,find:

a) **The total clock cycles and total running time of the program .**
b) **The instructions type that takes the maximum time of execution .**
c) **The instructions type that takes the minimum time of execution .**
d) **What is the efficiency of the processor ?**

Solution

a-Transfer instructions clock cycles=0.4x1000x7= 2800 clocks

Arithmatic instructions clock cycles= 0.3x1000x4= 1200 clocks

Logic instructions clock cycles = 0.15x1000 x 3= 450 clocks

Branching instructions clock cycles= 0.15x1000 x 5= 750clocks

TOTAL clocks = 5200 clocks

Clock time = 1/4MHz = 0.25 microseconds

TOTAL running time = 5200 x 0.25 = 1300 microsecond=

= 0.0013 second

b- Instructions type with maximum time is the data transfer instruction

c- Instructions type with minimum time is the logic instruction

D- Efficiency = Arithmatic & Logic & branching/ TOTAL

= 2400/5200 = 48% **(SLOW PROCESSOR)**

Computer History

- **The First Generation: Vacuum Tubes**
- **The Second Generation: Transistors**
- **The Third Generation: Integrated Circuits**

Table 1.2 Computer Generations

Generation	Approximate Dates	Technology	Typical Speed (operations per second)
1	1946–1957	Vacuum tube	40,000
2	1957–1964	Transistor	200,000
3	1965–1971	Small- and medium-scale integration	1,000,000
4	1972–1977	Large scale integration	10,000,000
5	1978–1991	Very large scale integration	100,000,000
6	1991–	Ultra large scale integration	>1,000,000,000

Evolution of Intel processors

Table 1.3 Evolution of Intel Microprocessors (page 1 of 2)

(a) 1970s Processors

	4004	8008	8080	8086	8088
Introduced	1971	1972	1974	1978	1979
Clock speeds	108 kHz	108 kHz	2 MHz	5 MHz, 8 MHz, 10 MHz	5 MHz, 8 MHz
Bus width	4 bits	8 bits	8 bits	16 bits	8 bits
Number of transistors	2,300	3,500	6,000	29,000	29,000
Feature size (μm)	10	8	6	3	6
Addressable memory	640 bytes	16 KB	64 KB	1 MB	1 MB

(b) 1980s Processors

	80286	386TM DX	386TM SX	486TM DX CPU
Introduced	1982	1985	1988	1989
Clock speeds	6–12.5 MHz	16–33 MHz	16–33 MHz	25–50 MHz
Bus width	16 bits	32 bits	16 bits	32 bits
Number of transistors	134,000	275,000	275,000	1.2 million
Feature size (μm)	1.5	1	1	0.8–1
Addressable memory	16 MB	4 GB	16 MB	4 GB
Virtual memory	1 GB	64 TB	64 TB	64 TB
Cache	—	—	—	8 kB

(c) 1990s Processors

	486TM SX	Pentium	Pentium Pro	Pentium II
Introduced	1991	1993	1995	1997
Clock speeds	16–33 MHz	60–166 MHz,	150–200 MHz	200–300 MHz
Bus width	32 bits	32 bits	64 bits	64 bits
Number of transistors	1.185 million	3.1 million	5.5 million	7.5 million
Feature size (μm)	1	0.8	0.6	0.35
Addressable memory	4 GB	4 GB	64 GB	64 GB
Virtual memory	64 TB	64 TB	64 TB	64 TB
Cache	8 kB	8 kB	512 kB L1 and 1 MB L2	512 kB L2

(d) Recent Processors

	Pentium III	Pentium 4	Core 2 Duo	Core i7 EE 4960X
Introduced	1999	2000	2006	2013
Clock speeds	450–660 MHz	1.3–1.8 GHz	1.06–1.2 GHz	4 GHz
Bus width	64 bits	64 bits	64 bits	64 bits
Number of transistors	9.5 million	42 million	167 million	1.86 billion
Feature size (nm)	250	180	65	22
Addressable memory	64 GB	64 GB	64 GB	64 GB
Virtual memory	64 TB	64 TB	64 TB	64 TB
Cache	512 kB L2	256 kB L2	2 MB L2	1.5 MB L2/15 MB L3
Number of cores	1	1	2	6