Computer Organization & Architecture

CHAPTER 01

Computer Architecture - attributes that have direct impact on the logical execution of a program.
- attributes ~~that~~ a system visible to a programmer.

Computer Organization - operational units and their interconnections that realize the architecture specifications.

Architectural attributes → instruction set, num of bit used to represent datatypes, I/O machanisms.

Organizational attributes → control singnals, interfaces between the computer and peripherals.

Architectural design issue → whether a computer will have a multiple instruction.

Organizational issue → whether that instruction will be implemented by a special multiply unit or by a machanism that makes repeated use of add unit of the system.

* A ~~fam~~ family of computer model → same architecture different organization.

* IBM System/370 architecture

Distinction between Computer Architecture & Computer Organization

Computer function & Computer Organization

Computer function: Computer function is about the operations that a computer is designed to perform. It describes what the computer does

There are four fundamental functions:

1. Data Processing – performing basic operation on data like arithmatic addition, substraction and logical comparison ~~ant~~, shifting
2. Data storage – the computer must store data at least temporarily while processing.
3. Data movement – computer must be able to communicate data.

   Input/output (I/O): movement between the computer and external (keyboard, display, disk, network)

   Internal: movement between internal component like CPU ⟷ Memory
4. Control – Directs all other components, Ensures that instructions are executed in the correct order,

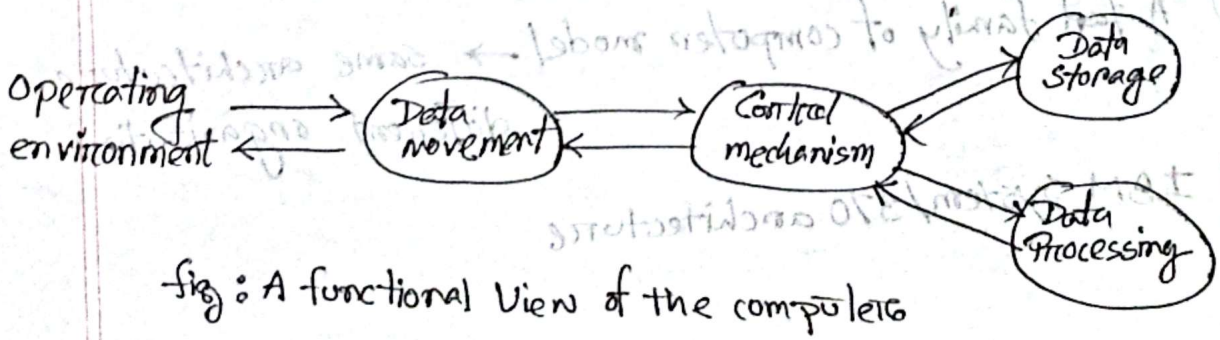

fig: A functional View of the computer

Computer ~~Architecture~~ Structure – is about the way components are organised so that the defined functions can be performed.

There are 4 major structural component :

1/ Central Processing Unit (CPU) – Controls the operation of the computer and performs its data processing functions (processor)

CPU further divided into –

i) Control Unit (CU) – directs operations

ii) Arithmetic Logic Unit (ALU) – Performs the computers data processing functions

iii) Registers – high-speed storage inside CPU.

iv) CPU Interconnection – provide communication among CU, ALU and registers.

2/ Main memory – stores both data and instructions temporarily

3/ I/O Modules – Moves data between the computers and its external environment (keyboard, monitor, disk, network)

4/ System interconnection :- A mechanism (bus) that provides communication paths among CPU, memory and I/O

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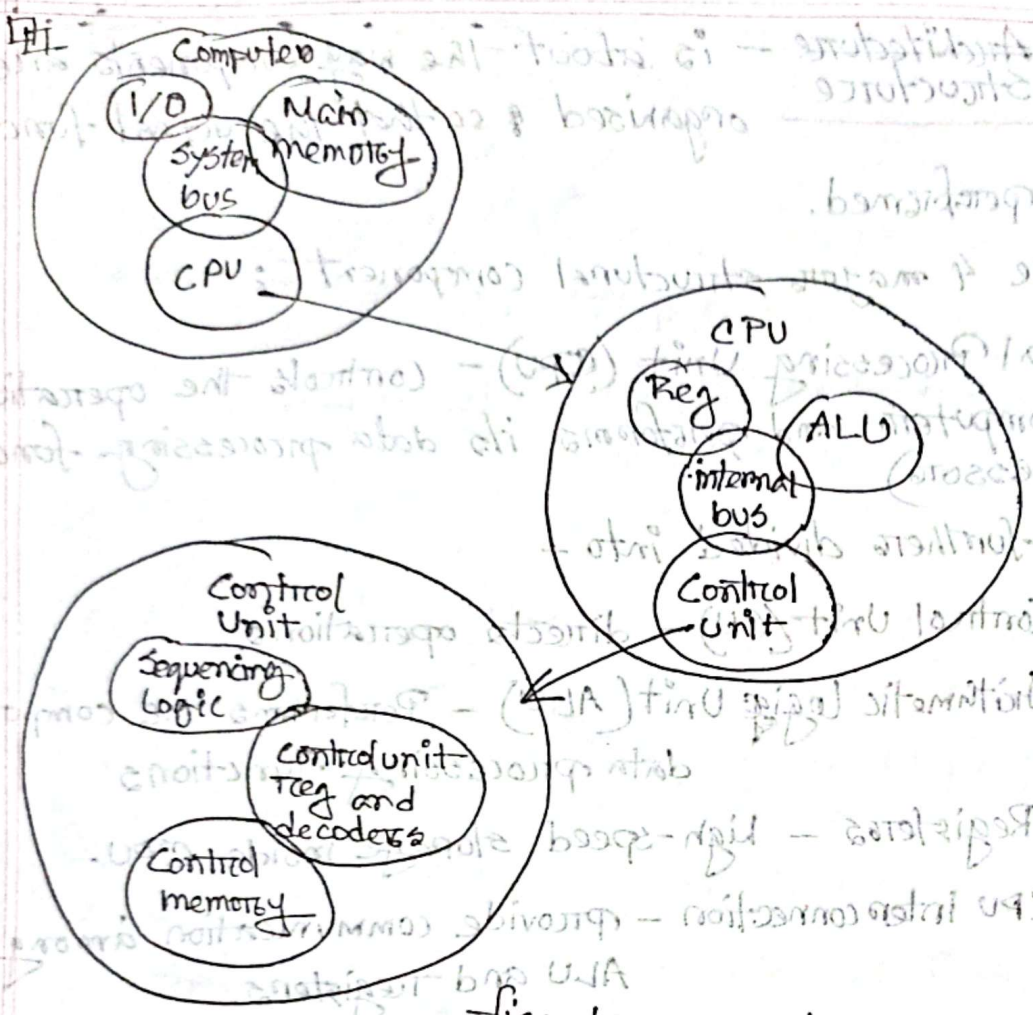


fig:- The computer: Top-level structure

Chap-02

2.1 History

1st Generation: Vacuum Tubes

☐ ENIAC – Electronic Numerical Integrator and Computer

→ World's first general purpose electronic digital computer

→ ~~wight~~ weighing 30 tons, 1500 square feet, more than 18000 vaccum tubes, 140 kwatt of power consumtion ~~during~~

→ 5000 additions/sec, faster than electro-mechanical computers

→ decimal machine – numbers were represented in decimal

→ memory consists 20 accumulators – each can hold 10 digit a ring of 10 vaccum tube represent each digit, at a time only one tube in ON state.

→ Drawback – ENIAC had to be programmed manually by seting switches and plugging and unplagging cables

☐ The Von Neumann machine –

→ Stored-program concept

→ IAS computers is the prototype of all subsequent general purpose computers.

Consists of – main memory, ALU, Control unit, I/O.

2.3

8080 → 8-bit

8086 → 16-bit, 1 Mbyte memory

8088 → used in IBM's 1st personal computer

80286 → 16-bit, 16 MByte memory

80386 → 32-bit, multitasking

80486 → pipelinging, builtin math coprocessor

Pentium → superscalar techniques,

" pro

" II:

" III:

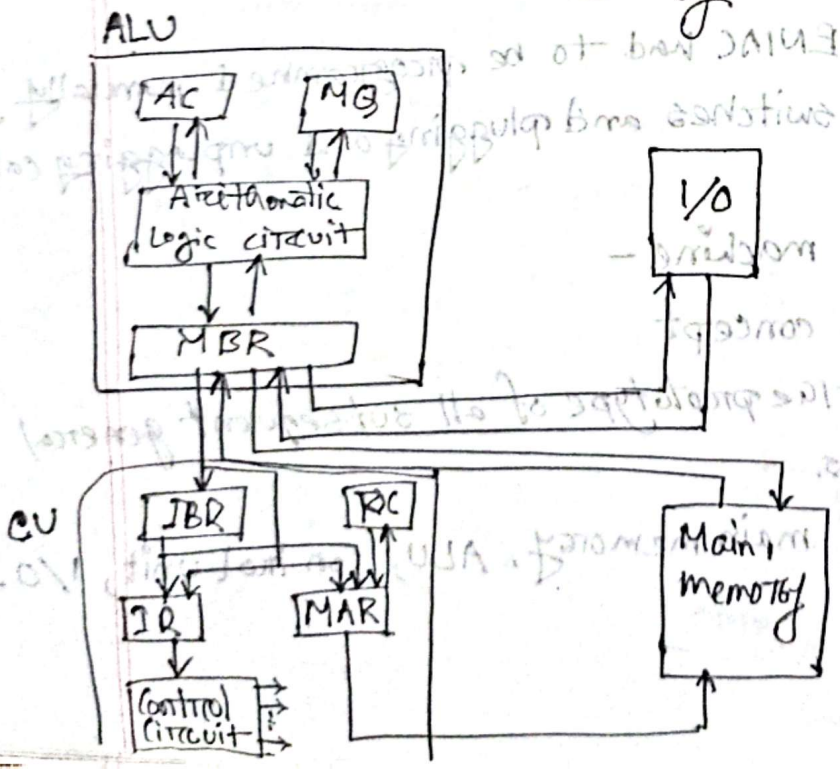
" 4:

Core: dual core, 2 processor on single chip

Core 2: 64-bit, 4 processor on single chip

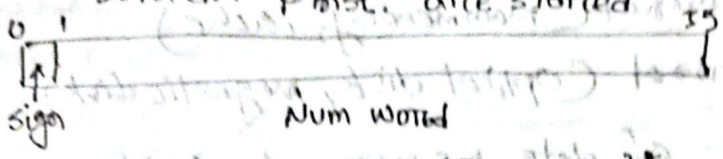
Von neumann Machine (IAS computer)

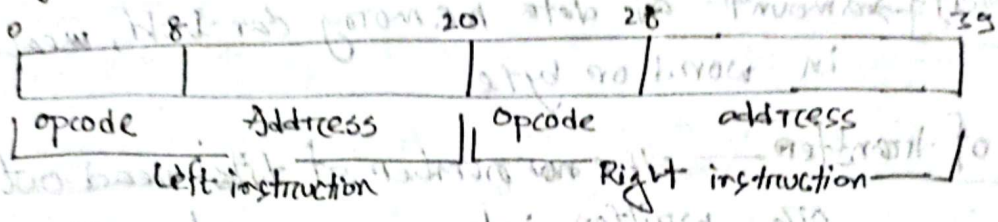
stored-program concept → both data & instruction can be stored in memory



A memory — 1000 storage location called words (40 bit)

↳ both data & inst. are stored





~~A tg~~ A IAS have 21 instructions

Data transfer, unconditional branch, conditional branch, Arithmetic, Address modify.

Chap 4

Key characteristics of computer memory

Location — Internal (main memory, cache)
External (optical disk, magnetic disk)

Capacity — amount of data memory can hold, measured in word or byte

Unit of transfer — the number of bits read out of or written into memory at a time

Access method (i) — Sequential (must go through data in order)
Direct (can skip to approximate location)
Random (any location accessed directly)
Associative (match by content not address)

Performance

access time (time it takes to read and write)
cycle time
transfer rate

Physical type — semiconductor, magnetic, optical.

Physical characteristics volatile, non-volatile, erasable, nonerraseable

Organization — memory modules for easier management and expansion.

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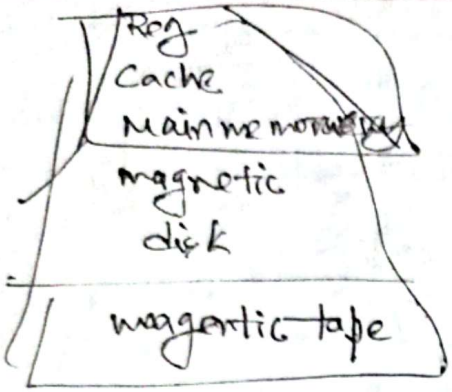
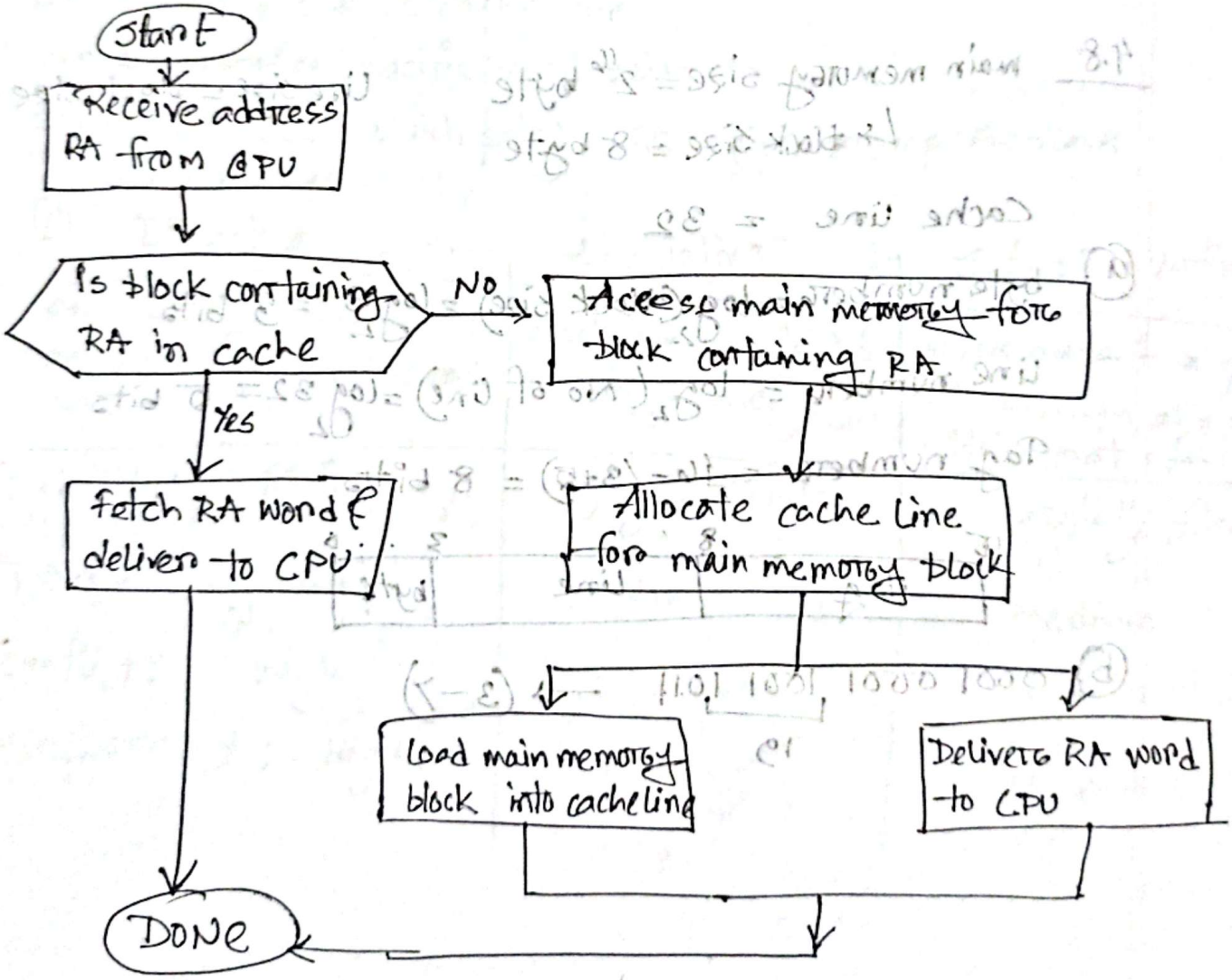
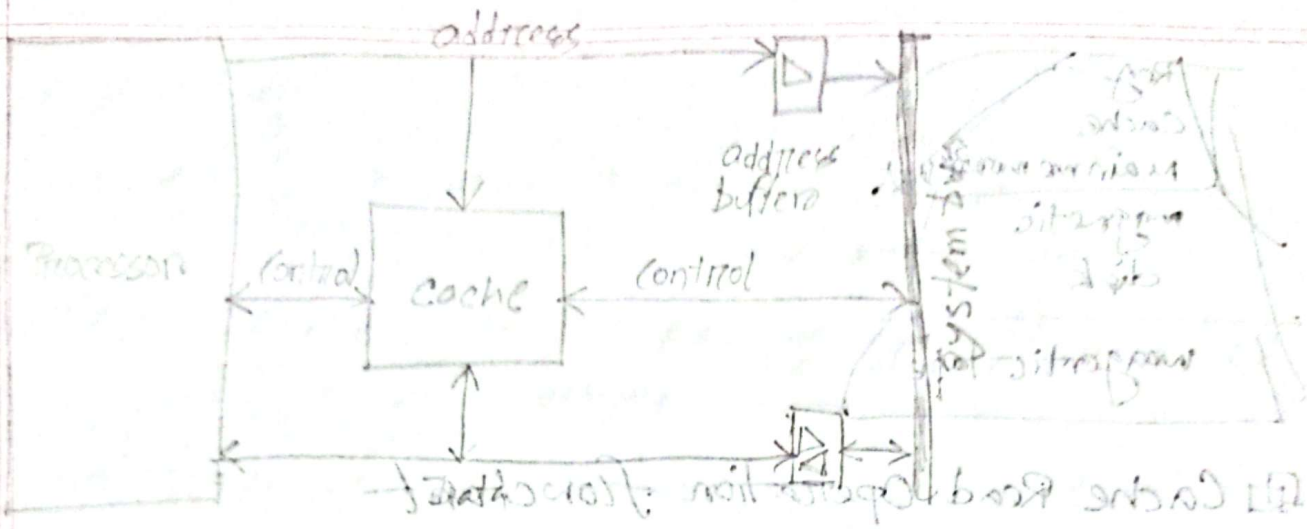


Cache Read Operation flowchart





4.8 main memory size = 2^{16} byte

↳ block size = 8 byte

Line size = block size

Cache line = 32

(a) byte numbers = $\log_2$(block size) = $\log_2 8$ = 3 bits

Line numbers = $\log_2$(No of line) = $\log_2 32$ = 5 bits

Tag numbers = 16 − (3+5) = 8 bits

15 ... 8	3 ... 0
tag	Line	byte

(b) 0001 0001 1001 1011 → (3 → 7)

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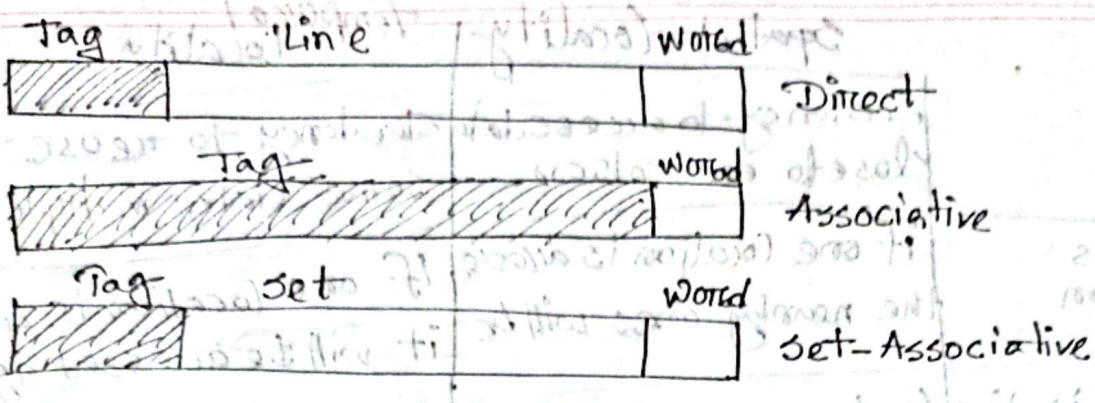


Tag - identifies which block of main memory is stored in the cache line

Line - selects specific cache line

Word - identifies specific word inside the block

Set - she selects which set in the cache contains the block

Direct	Associative	Set-Associative
each block of main memory maps to exactly one cache line	block can be placed in any line	block maps to a specific set, then to any line within that set
flexibility: Rigid	fully flexible	Partially flexible
Speed: very fast	slower	Medium
conflict: high	very low	Medium
Hardware cost: ~~High~~ low	high	Moderate

	Spatial Locality	temporal Locality
Def	tendency to access data close to each other	tendency to reuse the same data multiple times
Access Pattern	if one location is accessed the nearby ones will be	If one location is accessed, it will be accessed again
Optimization strategy	load memory block, prefetch sequencial data	keep recently accessed data in cache
Example	Accessing element of an array	~~Repp~~ Repeatedly using loop counter

4.1) 64 Line, $\frac{64}{4} = 16$ set

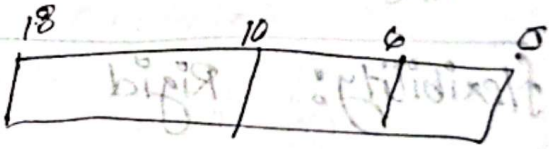
8K block of 64 words → 524288 words → 2^{19}

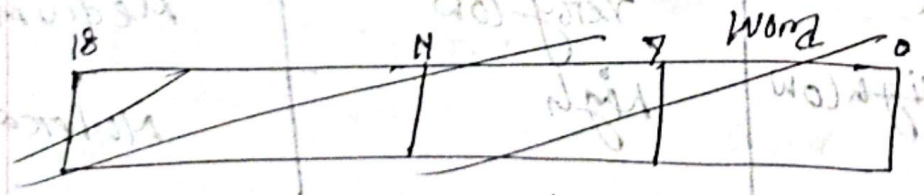
~~1048576 byte~~

~~word~~ byte num – 6 bits

set num – 4 bits

tag num = 19 – (6+4) = 9

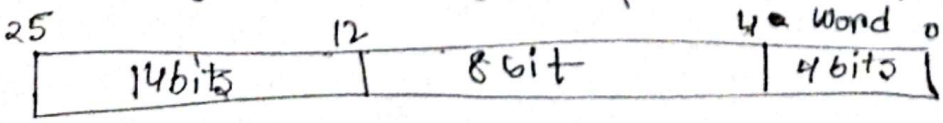


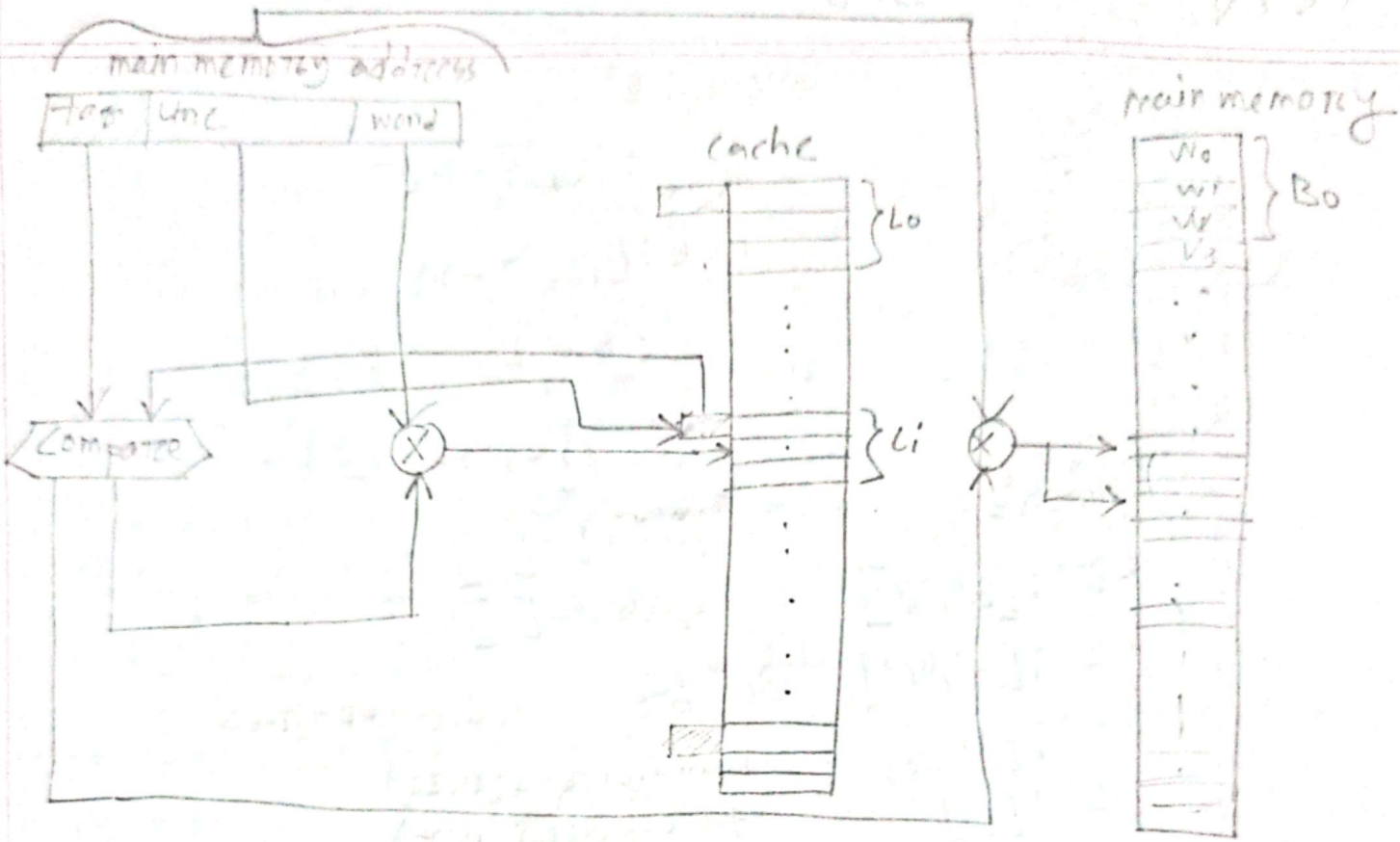


Line size = 16 byte = 2^4 bytes num of line = 512

Cache size = 8Kbyte = 2^{13} = 8192 bytes num of sets = $\frac{512}{2}$ = 256

Main memory size = 64 Mbyte = 2^{26} = 67108864 byte





main memory size $= 2^{24}$ byte

cache size $= 64$ kbyte $= 2^{16}$ byte

let, line size $= 8$ byte $= 2^3$ byte

$\therefore \frac{2^{16}}{2^3} = 2^{13}$ lines

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(a)

Tag(8)	Line(13)	word(3)

(b) address, 1111 1010 1011 1100 1110 1111

Tag = FAH line = 179DH word = 7H

(b) num of line $= \frac{2^{16}}{2^3} = 2^{13} \Rightarrow$ num of set $= 2^{13}/2 = 2^{12}$