CSC 212
UNIT 4 &5

Computer Memory

Computer Memory

- **Computer memory**: a term that refers to chip (electronic circuitry) based storage utilized strictly by the computer itself.
- It typically stores instructions/data currently being executed by the CPU, results of processing and other control programs needed for normal functioning of the computer

Classification Computer Memory

- Computer memory can be classified based on:

i. Volatility

a) Dynamic (volatile) memory – data is lost when power is switched off (temporal storage).

b) Static (non-volatile) memory - data is stored indefinitely

ii). Writability:

a) Random Access Memory (RAM) – it can be rewritten freely.

b) Read Only Memory (ROM) – can only be read but not written to.

- **N/B:** All ROM is static, but RAM can be either static or dynamic (dynamic is most common).

Categories of Computer Memory

- Computer memory comprises the following categories of memory:

i. RAM
ii. ROM
iii. Flash memory
iv. CMOS and
v. Cache memory

1. Random Access Memory (RAM)

- RAM is also called primary memory, main memory or simply, **memory**.
- It consists of memory chips that can be read from and written to by the processor and other devices in a random manner.
- Physically, RAM consists of electronic circuitry (chips) mounted on small rectangular circuit boards called **memory modules.**

- There are 2 types of memory modules:

i. **Single Inline Memory Modules (SIMMs) –** has pins on the opposite side of the circuit board that connects together at the base to form a single set of contacts.

ii. **Dual Inline Memory Modules (DIMMs)** - has pins on the opposite side of the circuit board that do not connect at the base thus form two

separate set of contacts.

- Most desktop and server computers today use DIMMs.
- Laptop (notebook) computers typically use a smaller type of memory module called Small Outline DIMM (SO-DIMM)

- MicroDIMMs are used on subnotebook computers and are smaller than SO-DIMMs.
- The DIMMS fit tightly into **memory (DIMM) slots** on the motherboard.

Characteristics of RAM

i. It has random access property.
ii. It is volatile.
iii. Fast access

RAM Functions

- RAM stores three basic categories of items:

i. Holds the operating system and other programs that control and maintain the computer and its devices.

ii. Applications that carry out a specific task

iii. The raw data being processed, intermediate and final results of processing.

- This role of RAM holding data and programs during execution is known as **stored program concept.**
- **N/B:** For a job to be executed by the CPU, both the data and instructions must be resident in the primary memory.

2. Read Only Memory (ROM)

- a non-volatile memory chip in which data can only be read and used but cannot be overwritten (changed).
- It is written to once, by the manufacturer during manufacturing.
- These ROM chips are also called **firmware**.

ROM Functions

i. Stores system data and instructions necessary for normal functioning of the computer hardware.

ii. Stores control programs needed for initial booting of the computer.

N/B: ROM stores data and

programs that are relatively permanent.

Types of ROM

1.Manufacturer (Masked)-Programmed (MROM)

- Data is burnt on the ROM by the manufacturer of the electronic equipment.

2.Programmable ROM (PROM)

- The user can load and store “read-only”

programs and data in it.

3.Erasable PROM (EPROM)

- The user can erase information stored in it and the chip can be reprogrammed to store new information.

4. Ultra Violet EPROM (UVEPROM)

- A type of EPROM chip in which the stored information is erased by exposing the chip for some time to

ultra-violet light

5.Electrically EPROM (EEPROM)

- A type of EPROM chip in which the stored information is erased by using high voltage electric pulses.
- Also called **Flash Memory**

3. Flash Memory

- A type EEPROM that stores data/instructions in non volatile chips that can be both erased and rewritten on electronically.
- Today, computers use flash memory to hold startup (booting) instructions
- Flash memory chips are also used to store data and programs on many devices: home appliances, smart phones, automotive devices etc.

- Flash memory is beginning to replace ROM technology.
- Reason: its easy to Flash Memory contents compared to ROM.

Reasons for Changing ROM Content

i. Repair

- Electrical surges and other hardware problems might corrupt the contents of ROM.
- **Flashing** the ROM to restore the boot loader instructions might correct the problem.

ii). User modification

- The boot loader may limit the programs that can be downloaded and run on a device.
- Flashing the ROM with a modified boot loader can bypass these limitations.
- The process is called "**jailbreaking**" on iOS devices

and “**rooting**” on Android devices.

iii).Forensics - Investigators may want to examine the BIOS for hidden data, and they may have to flash the BIOS to restore it to a non- destructive state.

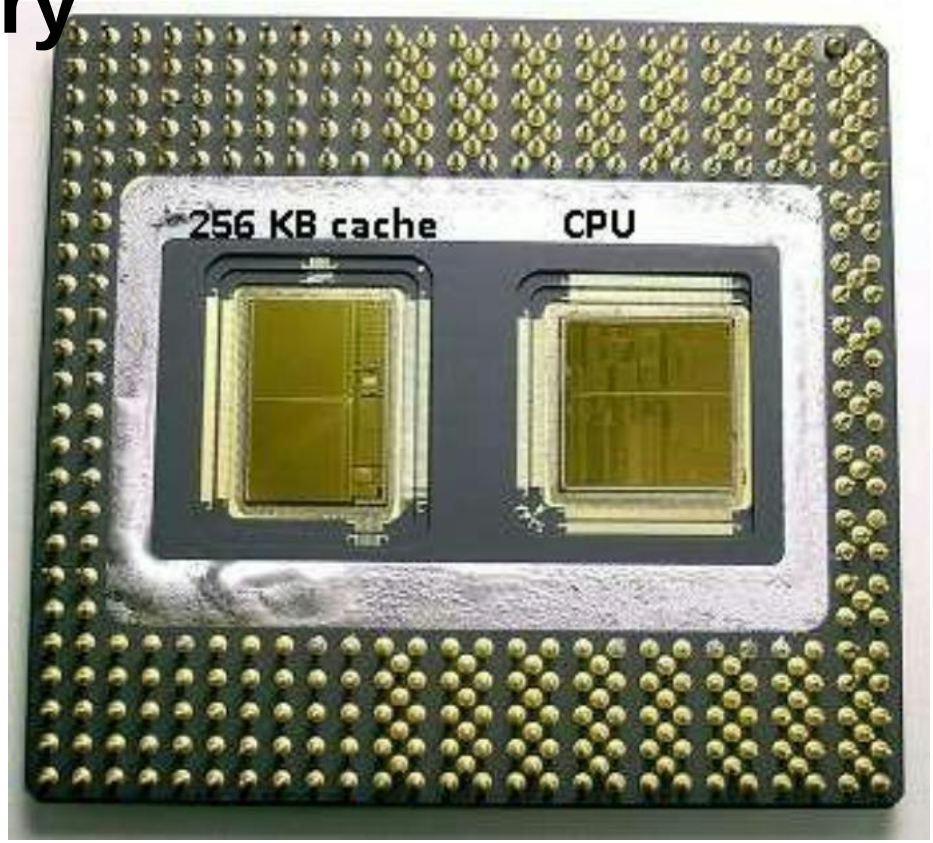
iv).updates. Device manufacturers offer updates to the boot loader as necessary to patch security weaknesses.

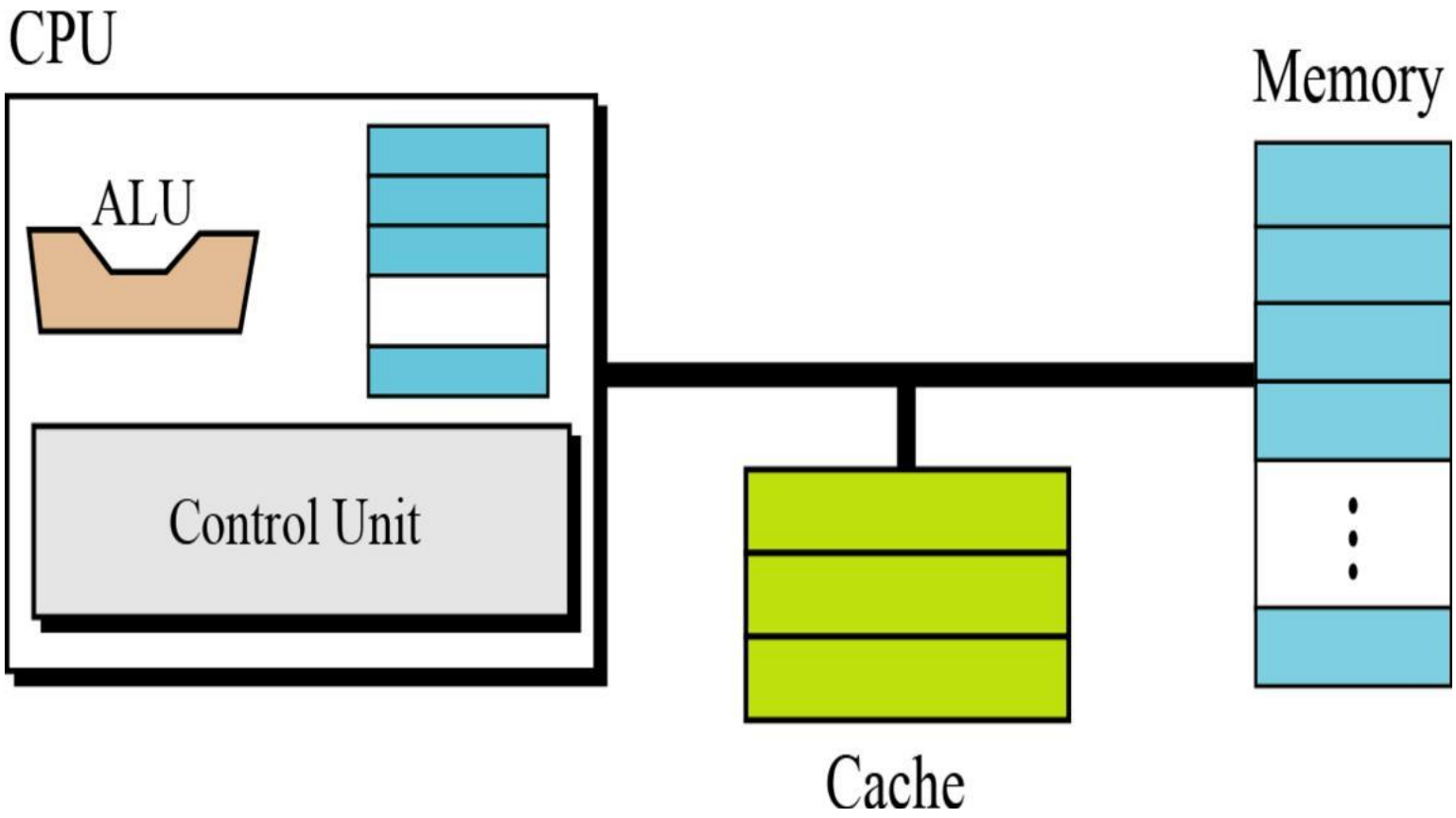
4. Complementary Metal Oxide Semiconductor (CMOS)

- CMOS memory chips are used to maintain **Real Time Clock** of the computer i.e. keep the calendar, date, and time current even when the computer is off.
- CMOS memory uses battery power to retain information even when

the power to the computer is off.

5. Cache Memory




CPU
ALU
Control Unit
Memory
Cache

- A small static RAM memory chip faster than the main memory but slower than the CPU, strategically placed between the CPU and main memory.
- It temporarily holds data and instructions that are very likely to be reused or needed next by the CPU (very **active** data/instructions).
- That way, when the CPU calls for the data, it’s

more readily available with less delay.

- Hence it helps reduce **CPU latency** thereby improving CPU performance.
- **Latency**: CPU idle time as it awaits for another component to deliver data.
- Computers have a multi-level cache system: Level 1 (L1), Level 2 (L2) and Level 3 (L3).

- L1 is the smallest and each of the other two caches is progressively larger.

- Cache memory level numbers indicate the order in which the various caches are accessed by the CPU when it requires new data or instructions:
  - L1 cache (which is the fastest type of cache but typically holds less data than other levels of cache) is checked first, followed by Level L2 cache, followed by L3 cache if it exists.
  - If the data/instructions are not found in cache memory, the CPU looks for them in RAM, which is slower than cache memory.
  - If the data/instructions cannot be found in RAM, then they are retrieved from the hard drive—an even much slower operation.

- Locating data in L1 is fastest because its small size
  i.e. there is no much data to go through.
- Generally, more cache memory results in faster processing.
- In modern PCs, all the three caches are located on the processor chip.
- Older processors have only L1 and L2, with the L3 being located on the motherboard.
- Most multi-core CPUs today have L1 and L2 cache dedicated to each core

with L3 cache shared among all the cores.

UNIT 5
RAM Technologies

Types of RAM

- Three basic types of RAM chips exist:

i).Dynamic RAM (DRAM)

- DRAM chips must be re-energized constantly otherwise they lose their contents.
- DRAMs are slow but inexpensive.

- Primary memory is made of DRAM chips.

ii). Static RAM (SRAM)

- These are chips do not have to be re- energized as often as DRAM chips, thus, the term static.
- SRAM is faster, more reliable but expensive compared to DRAM.
- Cache memory is made of SRAM chips.

- Traditionally RAM is volatile, however nonvolatile RAM (NVRAM) i.e. memory that retains its data even when power is switched off is under development.
- Eaxmples of such RAMs include:
  - Magneto-Resistive RAM
  - Memristor-based RAM

iii.Magneto-Resistive RAM (MRAM)

- MRAM uses magnetic polarization rather than electrical charges to store data
- MRAM has greater storage capacity, consumes less power, and has faster access times than electronic RAM.

iv). Memristor-based RAM

- uses memristors (short for memory resistors) that change their resistance in response to current flowing through them.

Applications for non-volatile RAM

1. Storing critical data for enterprise systems as they operate to guard against data loss.
2. Saving the data necessary to help industrial automation and robotics systems recover quickly from a power loss.
3. “Instant-on” computers and mobile devices that can be turned on and

off like an electric light, without any loss of data.

4.It is possible that nonvolatile RAM will in future eventually replace SDRAM as the main memory for a computer.

DRAM Technologies

Synchronous Dynamic RAM (SDRAM)

- DRAM that operates at the same speed as system (CPU) clock.
- That is, it's actions are synchronized with the system clock.
- Traditional DRAM technology is asynchronous

– its actions are not synchronized with the system clock.

SDRAM Variants

i).Single Data Rate (SDR)SDRAM

- This RAM moves one word of data per tick of the system clock.
- SDR SDRAM is found only in older systems.

ii). Double Data Rate (DDR) SDRAM

- DDR performs two actions per clock tick i.e. it transmits twice as much data as SDR in the same period.

iii). DDR2 SDRAM

- can perform four actions per clock tick i.e. it transmits twice as much data as DDR in the same period.

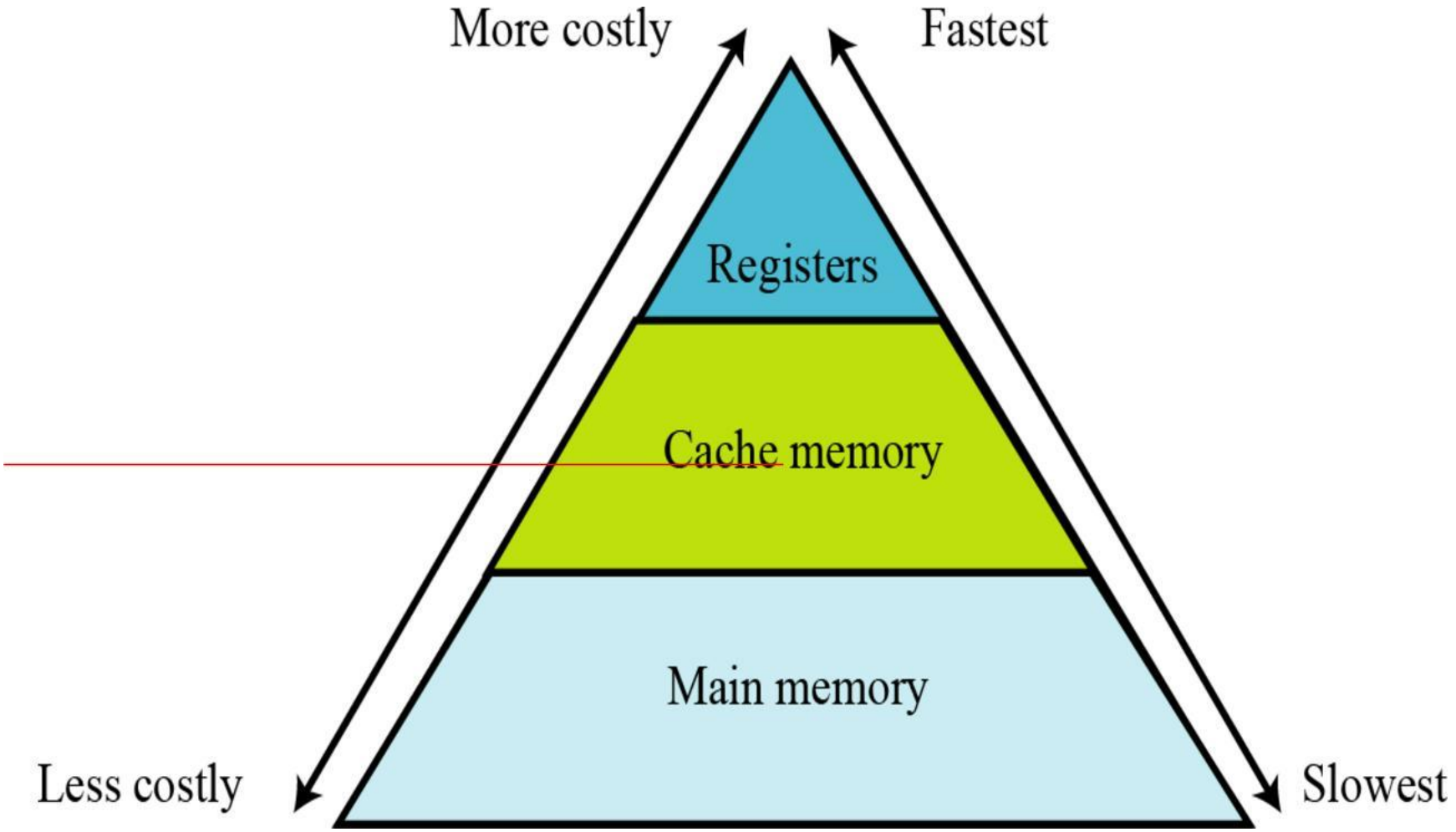
iv). DDR3 SDRAM

- Can perform eight actions per clock click. i.e. it transmits twice as much data as DDR2 in the same period.

v). DDR4 SDRAM

- keeps the same data rate as DDR3, but with less power consumption.

Memory Hierarchy



- Computer users need a lot of memory, especially memory that is very fast and inexpensive.
- This demand is not always possible to satisfy.
- Reason: very fast memory is usually very expensive.
- Therefore there is need to strike a

balance.

- The solution is hierarchical levels of memory such that:

i). Use a very small amount of costly high-speed memory where speed is crucial.

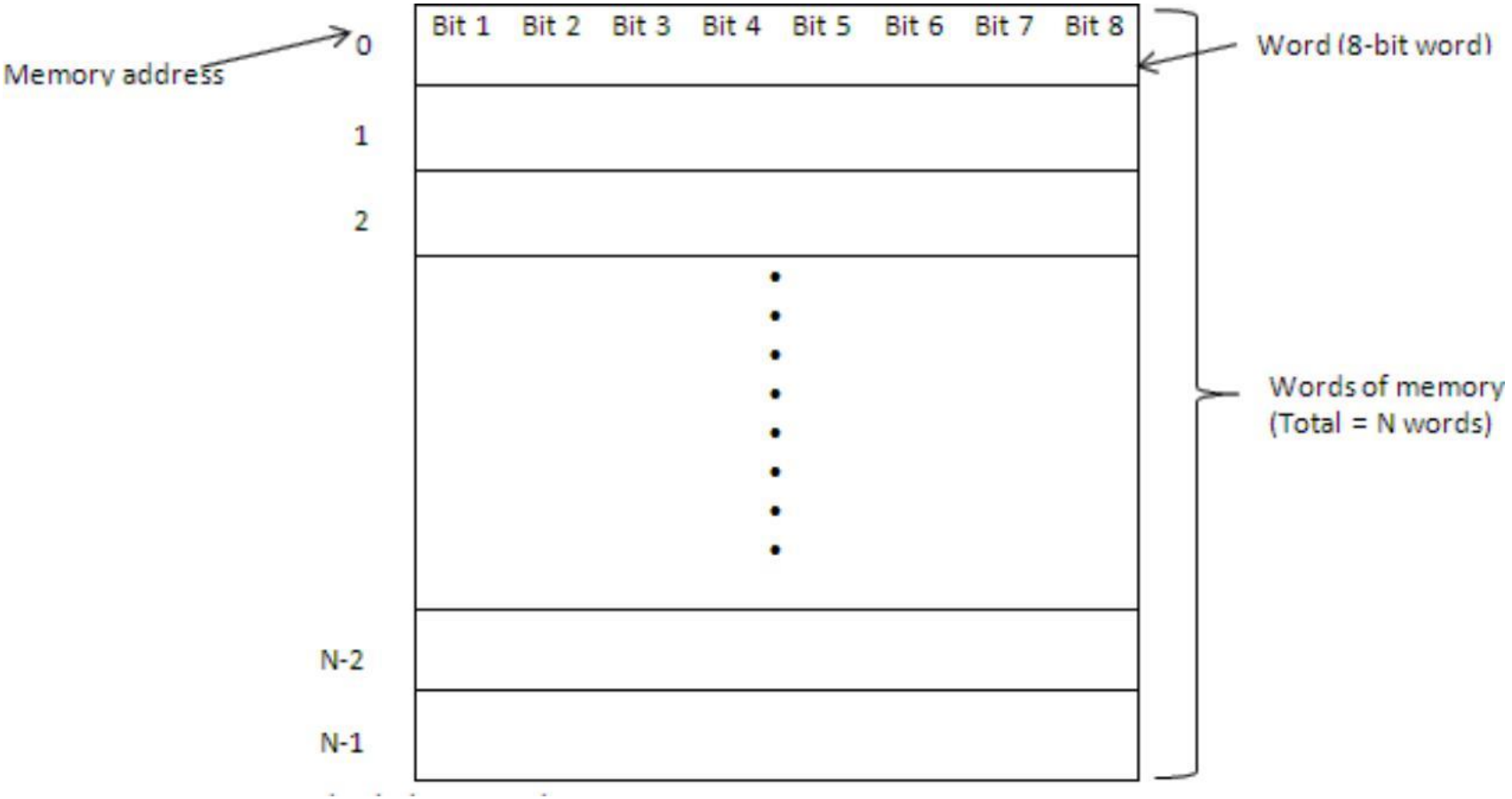
– The registers inside the CPU are purpose. ii). Use a moderate amount of medium-speed memory to store data that is accessed often.

– Cache memory is for this purpose.

iii). Use a large amount of low-speed memory for data that is accessed less often.

– Main memory is for this purpose.

Main Memory Organization



- Divided into groups of bits called **memory words**.
- Data is read from/written to memory word by word.
- Each word has equal number of bits **i.e.** 8-bits, 16-bits, 32-bits or 64-bit, called **word length, word size or word width.**
- Each word has a unique memory

address.

- The bigger the word-length, the faster the machine.
- An 8-bits word is called a **byte**.
- 16-bits word is called 2 bytes word, 32- bits word is called 4 bytes word etc.
- Typically, 1 byte holds 1 character .
- Therefore, the **Byte** is the

basic unit of storage in a computer.

Memory Capacity

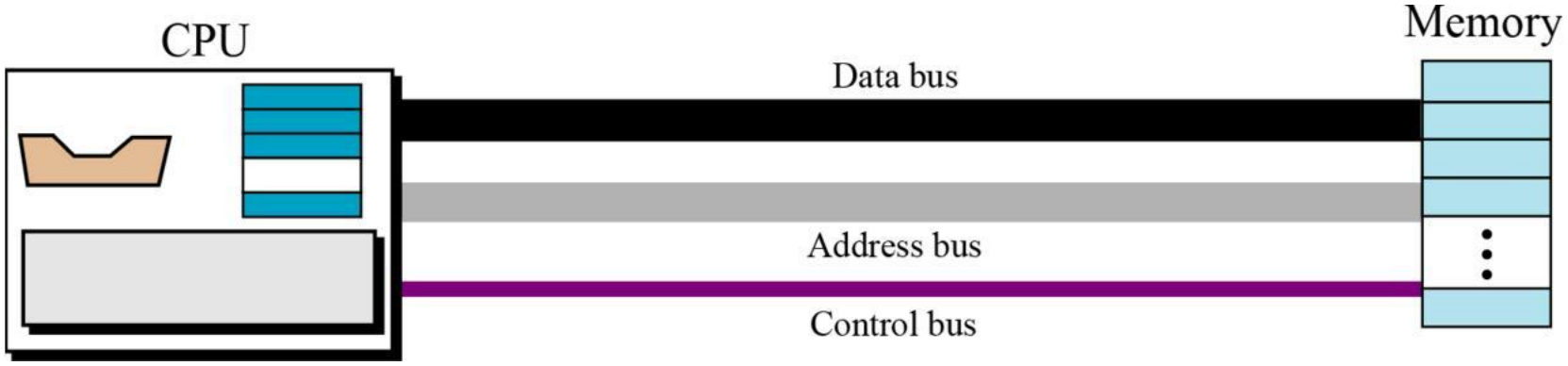
- is equal to the number of bytes that can be stored in its primary storage.
- Its units are:
  - ✓ Kilobytes (KB):1024 (2^{10}) bytes.
  - ✓ Megabytes (MB):1,048,576 (2^{20}) bytes.
  - ✓ Gigabytes (GB):1,073,741,824

(2^{30}) bytes

- ✓ Terabytes (TB): (2^{40}) bytes

Connecting CPU and Memory

- The CPU and memory are connected by three groups of connections, each called a **bus**: data bus, address bus, and control bus.



Data bus

- The data bus is made of several connections (paths), each carrying 1 bit at a time.
- The number of connections depends on the size of the word used by the computer.
- If the word is 32 bits (4 bytes), we need a data bus with 32 connections

so that all 32 bits of a word can be transmitted at the same time.

Address bus

- The address bus allows access to a particular word in memory.
- The number of connections in the address bus depends on the address space of the memory.
- If the memory has 2^n words, the address bus needs to carry n bits at a time. Therefore, it must have n

connections.

Control bus

- The control bus carries communication (control instructions e.g. read/write operation) between the CPU and memory.
- The number of connections used in the control bus depends on the total number of control commands a computer has (instruction set).
- If a computer has 2^m control actions, we need **m** connections for the control

bus, because m bits can define 2^m different operations.

Improving the Performance of Your System Today

1. Add more memory

- If your system is currently running on 4GB, upgrade to 8 or even 12 GB by replacing with higher memory modules or installing additional modules.

2. Perform system maintenance regularly
   - Uninstall programs properly

- Remove unnecessary programs from the Startup list

- Consider placing large files not needed on a regular basis on external storage
- Delete temporary files
- Error check and defrag the hard drive periodically
- Scan for viruses and spyware continually
- Clean out dust once or twice a year

3. Buy a larger or second hard drive
4. Upgrade your Internet connection

5. Upgrade your video graphics card

- if it is necessary to connect a second monitor to your computer, or if you are a gamer, computer artist, graphical engineer, or otherwise use 3D-graphic-intensive applications.