



Memory Hierarchy Design and its Characteristics

Last Updated : 19 Jun, 2023

In the [Computer System Design](#), [Memory Hierarchy](#) is an enhancement to organize the memory such that it can minimize the [access time](#).

The [Memory Hierarchy](#) was developed based on a program behavior known as [locality of references](#).

The figure below clearly demonstrates the different levels of the [memory hierarchy](#).

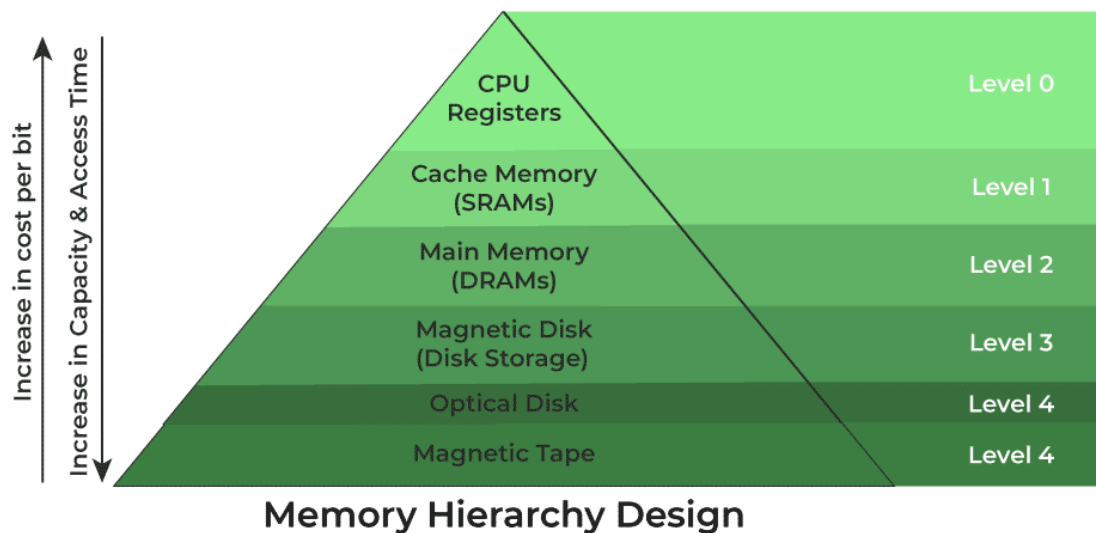
Why [Memory Hierarchy](#) is Required in the System?

[Memory Hierarchy](#) is one of the most required things in [Computer Memory](#) as it helps in optimizing the memory available in the computer. There are multiple levels present in the memory, each one having a different size, different cost, etc. Some types of memory like cache, and [main memory](#) are faster as compared to other types of memory but they are having a little less size and are also costly whereas some memory has a little higher storage value, but they are a little slower. Accessing of data is not similar in all types of memory, some have faster access whereas some have slower access.

Types of [Memory Hierarchy](#)

This [Memory Hierarchy Design](#) is divided into 2 main types:

- **[External Memory](#) or [Secondary Memory](#):** Comprising of [Magnetic Disk](#), [Optical Disk](#), and [Magnetic Tape](#) i.e. peripheral [storage devices](#) which are accessible by the processor via an [I/O Module](#).
- **[Internal Memory](#) or [Primary Memory](#):** Comprising of [Main Memory](#), [Cache Memory](#) & [CPU registers](#). This is directly accessible by the processor.



Memory Hierarchy Design

Memory Hierarchy Design

1. Registers

Registers are small, high-speed memory units located in the CPU. They are used to store the most frequently used data and instructions. Registers have the fastest access time and the smallest storage capacity, typically ranging from 16 to 64 bits.



2. Cache Memory

Cache memory is a small, fast memory unit located close to the CPU.

It stores frequently used data and instructions that have been recently accessed from the main memory.

Cache memory is designed to minimize the time it takes to access data by providing the CPU with quick access to frequently used data.

3. Main Memory

Main memory, also known as RAM (Random Access Memory), is the primary memory of a computer system.

It has a larger storage capacity than cache memory, but it is slower.

Main memory is used to store data and instructions that are currently in use by the CPU.

Types of Main Memory

- **Static RAM**: Static RAM stores the binary information in flip flops and information remains valid until power is supplied.

It has a faster access time and is used in implementing cache memory.

- **Dynamic RAM**: It stores the binary information as a charge on the capacitor.

It requires refreshing circuitry to maintain the charge on the capacitors after a few milliseconds.

It contains more memory cells per unit area as compared to SRAM.

4. Secondary Storage

Secondary storage, such as hard disk drives (HDD) and solid-state drives (SSD), is a non-volatile memory unit that has a larger storage capacity than main memory.

It is used to store data and instructions that are not currently in use by the CPU.

Secondary storage has the slowest access time and is typically the least expensive type of memory in the memory hierarchy.

5. Magnetic Disk

Magnetic Disks are simply circular plates that are fabricated with either a metal or a plastic or a magnetized material.

The Magnetic disks work at a high speed inside the computer and these are frequently used.

6. Magnetic Tape

Magnetic Tape is simply a magnetic recording device that is covered with a plastic film.

It is generally used for the backup of data. In the case of a magnetic tape, the access time for a computer is a little slower and therefore, it requires some amount of time for accessing the strip.

Characteristics of Memory Hierarchy

- **Capacity:** It is the global volume of information the memory can store. As we move from top to bottom in the Hierarchy, the capacity increases.
- **Access Time:** It is the time interval between the read/write request and the availability of the data. As we move from top to bottom in the Hierarchy, the access time increases.
- **Performance:** Earlier when the computer system was designed without a Memory Hierarchy design, the speed gap increased between the CPU registers and Main Memory due to a large difference in access time. This results in lower performance of the system and thus, enhancement was required. This enhancement was made in the form of Memory Hierarchy Design because of which the performance of the system increases. One of the most significant ways to increase system performance is minimizing how far down the memory hierarchy one has to go to manipulate data.

- **Cost Per Bit:** As we move from bottom to top in the Hierarchy, the cost per bit increases i.e. Internal Memory is costlier than External Memory.

Advantages of Memory Hierarchy

- It helps in removing some destruction, and managing the memory in a better way.
- It helps in spreading the data all over the computer system.
- It saves the consumer's price and time.

System-Supported Memory Standards

According to the memory Hierarchy, the system-supported memory standards are defined below:

Level	1	2	3	4
Name	Register	Cache	<u>Main Memory</u>	<u>Secondary Memory</u>
Size	<1 KB	less than 16 MB	<16GB	>100 GB
Implementation	Multi-ports	<u>On-chip/SRAM</u>	DRAM (capacitor memory)	Magnetic
<u>Access Time</u>	0.25ns to 0.5ns	0.5 to 25ns	80ns to 250ns	50 lakh ns
Bandwidth	20000 to 1 lakh MB	5000 to 15000	1000 to 5000	20 to 150
Managed by	Compiler	Hardware	<u>Operating System</u>	<u>Operating System</u>
Backing Mechanism	From cache	from <u>Main Memory</u>	from <u>Secondary Memory</u>	from ie

FAQs

1. What do you mean by Memory Hierarchy?

Answer:

Memory Hierarchy can be simply illustrated as the organization of the memory for saving the access time.

Because of the nicely written codes or program, memory hierarchy works well.

It takes less time in accessing at the current level.

2. Explain the types of Memory Hierarchy.

Answer:

Here are the some types of the Memory Hierarchy:

- External Memory or Secondary Memory
- Internal Memory or Primary Memory

3. In DBMS, How memory Hierarchy is listed?

Answer:

In Database Management System, Memory Hierarchy can be illustrated as follows:

- CPU Registers
- Cache Memory
- Main Memory or Primary Memory

Are you a student in Computer Science or an employed professional looking to take up the **GATE 2025 Test**? Of course, you can get a good score in it but

to get the best score our [GATE CS/IT 2025 - Self-Paced Course](#) is available on GeeksforGeeks to help you with its preparation. Get comprehensive coverage of all topics of GATE, **detailed explanations**, and **practice questions** for study. Study at your pace. Flexible and easy-to-follow modules. Do well in GATE to enhance the prospects of your career. Enroll now and let your journey to success begin!



R Risha... [+ Follow](#)

283

Previous Article

Introduction to memory and memory units

Next Article

Register Allocations in Code Generation

Similar Reads

Subprogram and its Characteristics

A Subprogram is a program inside any larger program that can be reused any number of times. Characteristics of a Subprogram: (1) A Subprogram is...

2 min read

Random Access Memory (RAM) and Read Only Memory (ROM)

Random Access Memory (RAM) is a type of computer memory that is used to temporarily store data that the computer is currently using or processing. RA...

5 min read

Difference between Random Access Memory (RAM) and Content...

Random Access Memory (RAM) is used to read and write. It is the part of primary memory and used in order to store running applications (programs)...

4 min read

Difference between Virtual memory and Cache memory

Cache Memory: Cache memory increases the accessing speed of CPU. It is not a technique but a memory unit i.e a storage device. In cache memory, recently...

2 min read

Difference between Uniform Memory Access (UMA) and Non-uniform...

Multiprocessors can be categorized into three shared-memory model which are: Uniform Memory Access (UMA) Non-uniform Memory Access...

4 min read

[View More Articles](#)

Article Tags :

[Computer Organization & Architecture](#)

[GATE CS](#)



Corporate & Communications Address:- A-143, 9th Floor, Sovereign Corporate Tower, Sector- 136, Noida, Uttar Pradesh (201305)
| Registered Address:- K 061, Tower K, Gulshan Vivante Apartment, Sector 137, Noida, Gautam Buddh Nagar, Uttar Pradesh, 201305



Company

About Us
Legal
In Media
Contact Us
Advertise with us
GFG Corporate Solution
Placement Training Program
GeeksforGeeks Community

DSA

Data Structures
Algorithms
DSA for Beginners
Basic DSA Problems
DSA Roadmap
Top 100 DSA Interview Problems
DSA Roadmap by Sandeep Jain
All Cheat Sheets

Languages

Python
Java
C++
PHP
GoLang
SQL
R Language
Android Tutorial
Tutorials Archive

Data Science & ML

Data Science With Python
Data Science For Beginner
Machine Learning Tutorial
ML Maths
Data Visualisation Tutorial
Pandas Tutorial
NumPy Tutorial
NLP Tutorial

Web Technologies

- HTML
- CSS
- JavaScript
- TypeScript
- ReactJS
- NextJS
- Bootstrap
- Web Design

Computer Science

- Operating Systems
- Computer Network
- Database Management System
- Software Engineering
- Digital Logic Design
- Engineering Maths
- Software Development
- Software Testing

System Design

- High Level Design
- Low Level Design
- UML Diagrams
- Interview Guide
- Design Patterns
- OOAD
- System Design Bootcamp
- Interview Questions

School Subjects

- Mathematics
- Physics
- Chemistry
- Biology
- Social Science
- English Grammar
- Commerce
- World GK

Python Tutorial

- Python Programming Examples
- Python Projects
- Python Tkinter
- Web Scraping
- OpenCV Tutorial
- Python Interview Question
- Django

DevOps

- Git
- Linux
- AWS
- Docker
- Kubernetes
- Azure
- GCP
- DevOps Roadmap

Interview Preparation

- Competitive Programming
- Top DS or Algo for CP
- Company-Wise Recruitment Process
- Company-Wise Preparation
- Aptitude Preparation
- Puzzles

GeeksforGeeks Videos

- DSA
- Python
- Java
- C++
- Web Development
- Data Science
- CS Subjects

@GeeksforGeeks, Sanchhaya Education Private Limited, All rights reserved