Evolution of Programming Languages and CPU Interaction

1. CPU and Machine Language

- The **CPU/MP** (Microprocessor) operates based on **semiconductor technology**.
- It processes **binary signals** using **transistors**:
  - **NPN Transistor:** 0V represents **0**
  - **PNP Transistor:** 5V represents **1**
- The CPU directly understands **Machine Level Language (MLL)**, which consists of **binary instructions** (e.g., `00100`, `10100`, `00101`).

2. Levels of Programming Languages

- **Machine Level Language (MLL):**
  - Uses binary codes (`0` and `1`)
  - Directly understood by CPU
  - Difficult for humans to write and debug
- **Assembly Level Language (ALL):**
  - Uses symbolic mnemonics like `ADD`, `SUB`, `DIV`
  - Easier to write than MLL but still hardware-dependent
  - Needs an **Assembler** to convert into MLL
- **High-Level Language (HLL):**
  - Uses user-friendly syntax (`+`, `-`, `/`, `*`, `print`, `scan`, `if`, `else`)
  - Independent of hardware
  - Requires a **Compiler** to translate into MLL

3. Translation Process

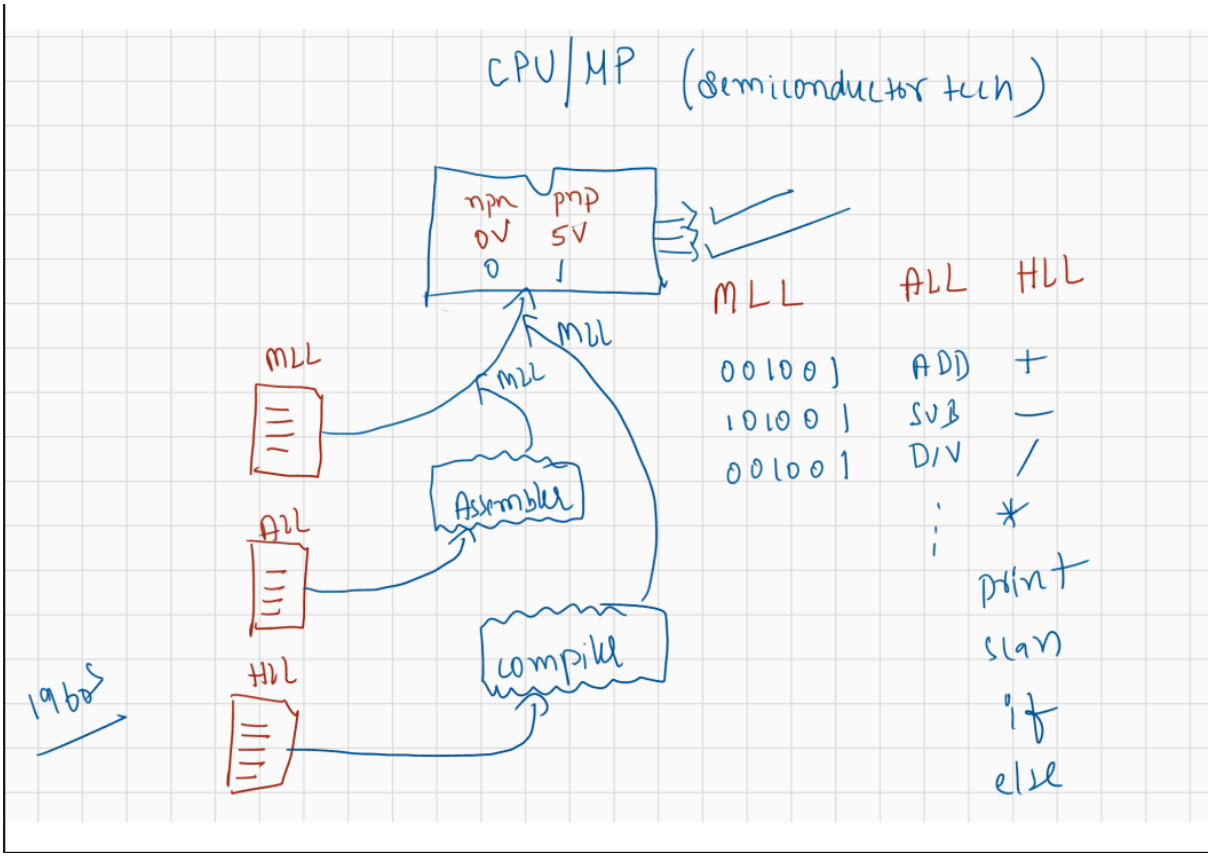
- **Assembler:** Converts **Assembly Level Language (ALL)** into **Machine Level Language (MLL)**.
- **Compiler:** Converts **High-Level Language (HLL)** into **Machine Level Language (MLL)**.

4. Historical Context

- The **1960s** saw the evolution from machine-level coding to **Assembly Language** and later **High-Level Languages**, making programming more accessible.

Conclusion

The transition from **MLL** → **ALL** → **HLL** improved programming efficiency, allowing easier development and broader usability across different hardware architectures.



Understanding Computer Memory and Storage

Notes

1. Computer Memory and Storage Overview

- Computers use memory and storage to manage data efficiently.
- Memory (RAM) is temporary, while storage (HDD/SSD) is permanent.

2. Types of Storage Devices

HDD (Hard Disk Drive)

- Uses **magnetic technology** to store data.
- **Advantages**: Cost-effective, non-volatile, large storage capacity.
- **Disadvantages**: Slower read/write speeds, bulky design.

SSD (Solid State Drive)

- Uses **flash memory** instead of magnetic disks.
- **Advantages**: Faster speed, lightweight, energy-efficient, reduces system boot time.
- **Disadvantages**: More expensive than HDDs.

3. Random Access Memory (RAM)

- **Volatile memory** that temporarily stores active programs.
- Faster than HDD/SSD but loses data when power is off.
- Improves system performance and multitasking capability.

4. Cache Memory

- Small, high-speed memory located close to the CPU.
- Stores frequently accessed data to enhance speed.
- Reduces the time required for the processor to fetch data.

5. Data Flow in a Computer

- Files are stored in HDD/SSD as permanent data.
- When accessed, files are loaded into RAM for quick processing.
- Frequently used data moves to cache memory for even faster access.
- The CPU fetches, processes, and executes data.
- Processed data can be displayed or saved back to storage.

Essay: How Computers Handle Files and Memory

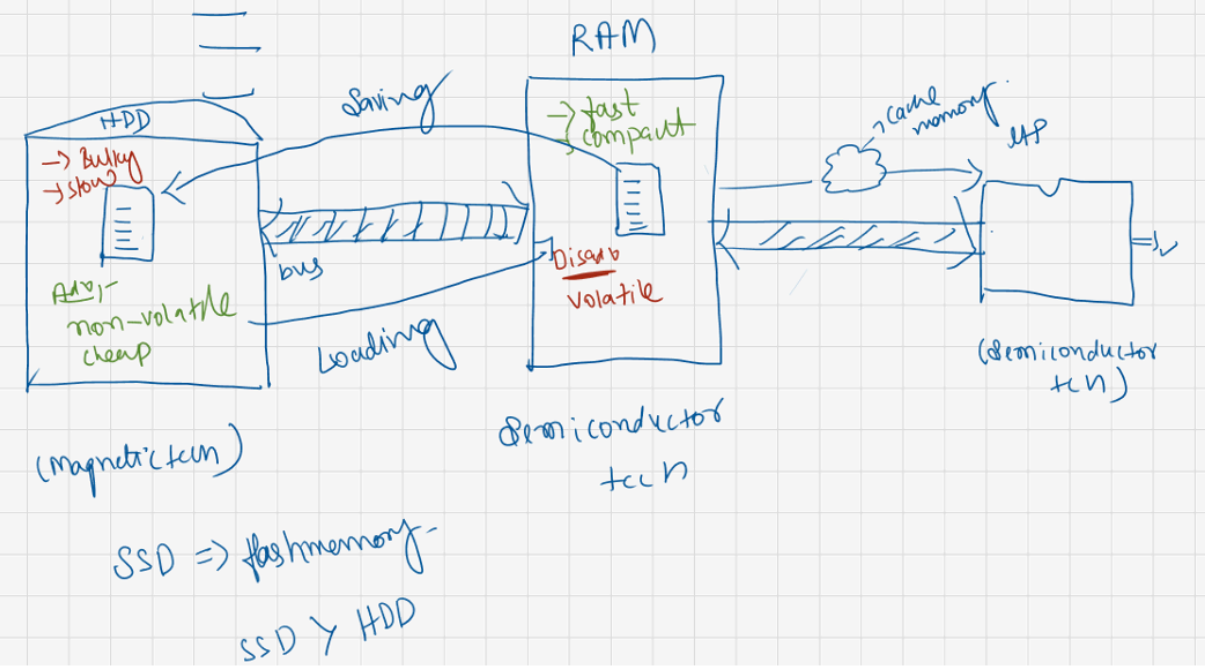
Computers handle files and memory using a well-structured system of storage and processing. When a file is saved, it is stored permanently on a secondary storage device such as an HDD or SSD. When the file is needed, the operating system retrieves it and loads it into RAM, where it can be accessed much faster than from a storage drive.

HDDs have long been used for storage because they are affordable and can store large amounts of data. They use magnetic disks to read and write data, making them non-volatile, meaning they retain information even when powered off. However, HDDs are slower and bulkier compared to modern alternatives. On the other hand, SSDs use flash memory, allowing much faster access to files and applications. This enhances overall system performance, reduces loading times, and improves user experience.

RAM plays a crucial role in a computer's speed and performance. Unlike storage devices, RAM is a temporary, volatile memory that holds active programs and files. It allows the CPU to access and process data quickly, ensuring smooth performance during multitasking. Additionally, cache memory, a smaller but even faster memory, further optimizes performance by storing frequently used data closer to the CPU. This reduces the time needed to fetch data, improving processing efficiency.

The flow of data within a computer follows a structured path. When a file is requested, it moves from storage to RAM via the system bus. The CPU then fetches the necessary instructions, processes them, and executes commands. If specific data is frequently used, it is temporarily stored in cache memory to speed up future access. Once processing is completed, the data can either be displayed to the user or saved back to storage.

In conclusion, an efficient computing system requires a well-balanced combination of **fast storage (SSDs), sufficient RAM, and optimized cache memory**. SSDs significantly improve speed, RAM enhances real-time data processing, and cache memory optimizes CPU performance. Understanding these components helps users make informed decisions regarding hardware upgrades and optimizations, ensuring a smoother and faster computing experience



NOTES FORMAT

How a Computer Uses a File?

1. **Source File**
    - A file written in a programming language (e.g., Java, C, etc.).
    - Stored in **HDD (Hard Disk Drive)**.
    - Needs to be converted into machine-readable format.
2. **Compiler**
    - Converts source code into **object file (.obj)**.
    - Object file is an incomplete file and needs further processing.
    - Converts **High-Level Language (HLL) → Machine-Level Language (MLL).**

3. **Linker**
    - Combines object files with library files.
    - Produces an **Executable File (.exe).**
4. **Loader**
    - Loads the **.exe file** into **RAM** for execution.
    - Managed by the **Operating System**.
5. **Execution in CPU**
    - The program is executed by the **CPU** using **cache memory**.
    - RAM provides temporary storage; data is processed in **Main Memory**.
6. **Memory Types**
    - **HDD (Hard Disk Drive)** → Non-volatile storage, stores files permanently.
    - **RAM (Random Access Memory)** → Volatile memory, holds data temporarily for quick access.
    - **Cache Memory** → Small, high-speed memory close to CPU for faster execution.

ESSAY FORMAT

How Does a Computer Use a File?

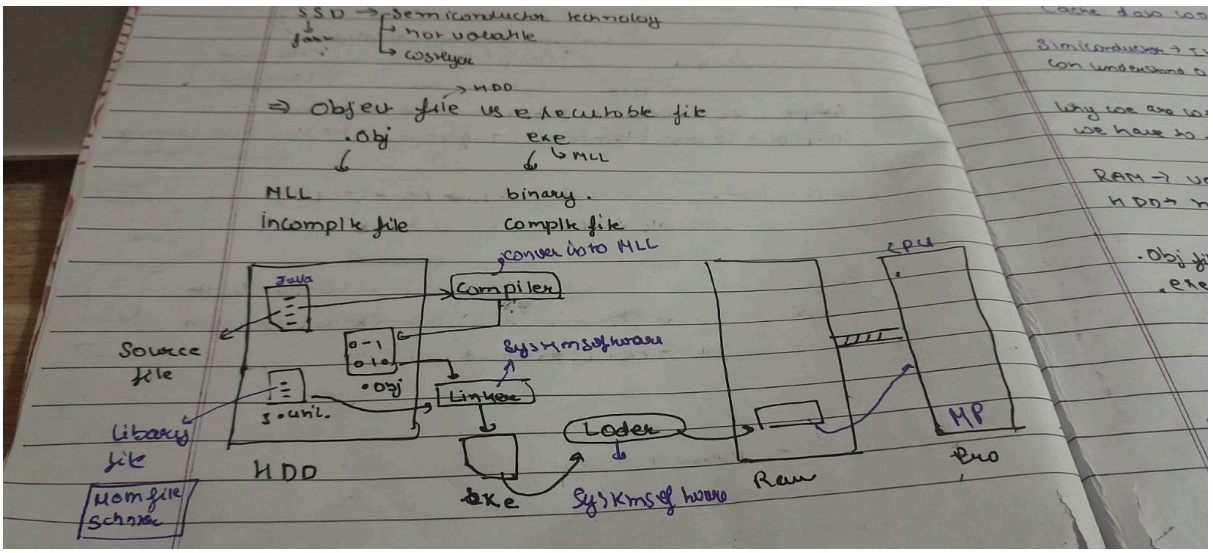
Computers use different types of files for processing and execution. A **source file** is a program written in a high-level language such as Java or C. This file is stored on the **hard disk (HDD)** but cannot be directly executed by the computer. It needs to be converted into a machine-understandable format.

The **compiler** plays a crucial role in this process. It translates the source code into an **object file (.obj)**, which contains machine code but is incomplete. The **linker** then combines this object file with required library files to create an **executable file (.exe).**

Once the executable file is created, it needs to be loaded into **RAM (Random Access Memory)** for execution. This is done by the **loader**, which is part of the operating system. The CPU then executes the program using data stored in **cache memory**, which allows faster access to frequently used information.

The computer's memory system plays a key role in file execution. **HDD** is a non-volatile storage where files are stored permanently, while **RAM** is a temporary, volatile memory that provides fast access during execution. Additionally, **cache memory** speeds up processing by keeping frequently accessed data close to the CPU.

In summary, a computer follows multiple steps to use a file—from storing, compiling, linking, and loading to execution in the CPU. The coordination between **HDD, RAM, cache memory, and CPU** ensures efficient processing and performance.



1. Why is an Object File (.obj) Incomplete After Compilation?

- When a compiler converts **High-Level Language (HLL)** code (like C, Java) into **Machine-Level Language (MLL)**, it **only** translates the main program but does **not** include external dependencies (like library files).
- The object file (**.obj**) still needs **linking** with library files before it becomes a complete **executable file (.exe)**.
- **Reason:** It helps manage complexity and optimizes execution by linking only necessary libraries.
- **Example:**
    - If your program uses `printf()`, the function is in the C Standard Library (`stdio.h`), which is linked later by the **linker**.

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2. Assembler vs. Compiler

Feature	Assembler	Compiler
Input Language	**Assembly Language (ALL)** (low-level)	**High-Level Language (HLL)** (Java, C, Python)
Output Language	**Machine Code (MLL)**	**Machine Code (MLL)**

Example Code	`MOV AX, 05` → `10110000 00000101`	`int x = 5;` → `10110000 00000101`
Role	Converts Assembly Language to Machine Language	Converts HLL to Machine Language
Example Tools	MASM, NASM	GCC, JDK, Clang

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3. Does the Processor Have Memory?

Yes, but **very limited**!

- The **CPU has Registers** (like AX, BX, CX in x86 architecture) which store frequently used instructions.
- The **Cache Memory** is inside the CPU and stores frequently accessed data to **reduce time complexity**.
- **Example:** If a CPU executes `x = x + 5;` repeatedly, it fetches `x` from the cache instead of RAM.

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4. How Does Cache Memory Recognize Repeated Commands?

- The **Operating System (OS)** and CPU use **caching algorithms** like:
  - **LRU (Least Recently Used)** – removes least-used data.
  - **FIFO (First In First Out)** – replaces old cache data first.
- If a program runs multiple times, cache stores important data, improving performance.

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5. What is Semiconductor Technology?

- **Semiconductors** (made of **silicon diodes**) control electric current and store **0s and 1s**.
- Used in **transistors, processors, memory (RAM, SSD), and logic gates**.
- **Example:** In **SSD (Solid-State Drive)**, data is stored using NAND-based semiconductor flash memory.

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6. Why Do We Write Programs in RAM if HDD is Permanent Storage?

- **RAM is Faster** than HDD (RAM: ~100ns, HDD: ~10ms).
- **Execution needs fast access**, and CPU can only process data in **RAM, not HDD**.
- **After execution,** data is saved back to HDD for permanent storage.

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7. Recap: Object File (.obj) vs. Executable File (.exe)

File Type	Description
.obj File (Object File)	Intermediate file after compilation, **not complete**, needs linking.
.exe File (Executable File)	Fully compiled and linked file, **ready for execution**.

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8. What is a Register?

- **Registers** are **tiny memory units inside the CPU**.
- Stores **temporary data and instructions** for quick execution.
- Example: **AX, BX, CX** in Intel x86 processors.

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9. What is a Byte?

- A **byte** is the **smallest unit of memory** in a computer.
- **1 byte = 8 bits**.
- **Where it is used?**
    - **Files → HDD (Hard Disk)**
    - **Bytes → RAM (Random Access Memory)**
    - **Registers → CPU (Microprocessor)**

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10. Why Can’t We See Library Files (.lib) Like Normal Files?

- Library files are in **Machine-Level Language (MLL)** (binary format).
- If you open them, you'll see **garbage characters**.
- **Example:** `.dll` in Windows, `.so` in Linux.

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11. Is Data Stored in Bytes When Loaded from HDD to RAM?

Yes!

- The OS **manages memory in bytes**.
- When a file is loaded, it is stored in **blocks of bytes** in RAM.

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12. Java Learning Roadmap

- **Java SE (Core Java)**
- **Java EE (Advanced Java)**
    - Requires: **HTML, CSS, JavaScript (basics)**
- **Databases:** MySQL, Oracle

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13. When You Reopen an App, What Does the Processor Use – Cache or RAM?

System State	Where Data is Stored?
Laptop OFF	Memory is cleared (HDD is used).
Laptop in Sleep Mode	Data remains in RAM and Cache (faster reopening).

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14. Did the Compiler Replace the Assembler?

No.

- **Assembler is still used** for low-level programming.
- **Compilers are for HLL → Machine Code**, but **Assembler is needed** for Assembly Language.

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15. Is Linker Available in Java?

Yes!

- Java uses a **"Just-In-Time" (JIT) Compiler** that **links classes dynamically** at runtime.

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16. Total Sessions in Advanced Java & Spring Boot

- **Advanced Java: 50+ hours**
- **Spring Boot + Microservices: 80+ hours**

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17. What Comes with C Language Installation?

When you install C (e.g., **Turbo C, GCC**), you get: ✅ Compiler
✅ Linker
✅ Loader
✅ Library Files

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18. Difference Between HDD and SSD

Feature	HDD (Hard Disk Drive)	SSD (Solid-State Drive)
Speed	Slower (~100 MB/s)	Faster (~500 MB/s - 7000 MB/s)
Durability	Mechanical (prone to damage)	No moving parts (more durable)
Technology	Magnetic Storage	Semiconductor (Flash Memory)
Price	Cheaper	Expensive

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19. Is Cache Memory Inside the CPU or Separate?

- Cache Memory is **inside the CPU**.
- Used for **storing frequently accessed data**.
- **Size:** Small (~1MB to 64MB).

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20. Can a Program Run Without Saving?

No!

- The OS **must save the file** before execution.
- **Without saving, OS cannot load the program into RAM.**

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21. What Does Assembly Language Look Like?

Example:

assembly

CopyEdit

```
MOV AX, BX    ; Move data from BX to AX

ADD AX, 5     ; Add 5 to AX
```

- These instructions are converted into **Machine Code (Binary)**.

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22. Java Installation Issues (JDK19 + Eclipse)

- Eclipse **must support JDK version**.
- Latest Eclipse **supports only JDK17**.
- **Solution:** Install **JDK8 or JDK11 (LTS version).**

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23. Difference Between Linker & Loader

Software	Function

Linker	Combines `.obj` files with libraries to create `.exe`.
Loader	Loads `.exe` into **RAM** for execution.

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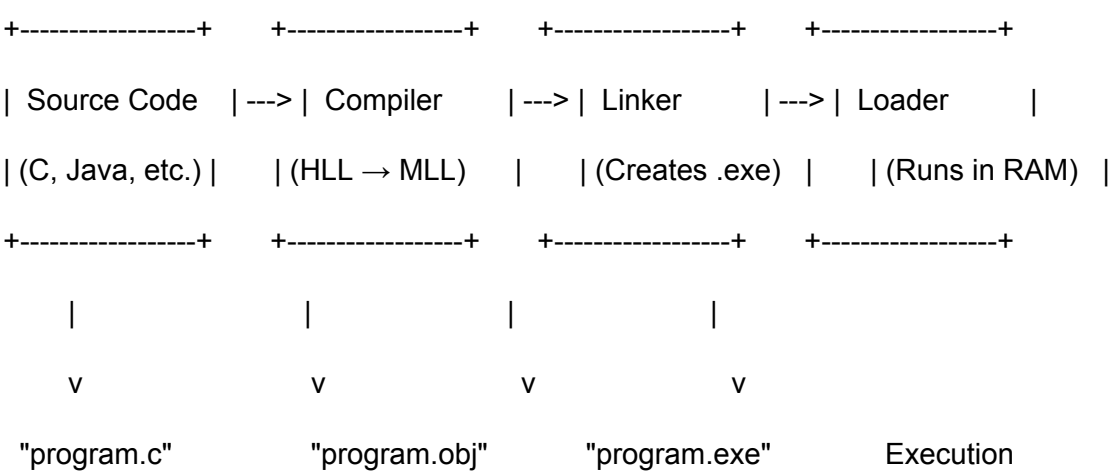
24. How is Data Transferred from RAM to CPU?

- Data is moved via the **System Bus (Data Bus, Address Bus, Control Bus).**
- The OS **loads the file into RAM**.
- **Then, CPU fetches instructions from RAM → Registers → Execution.**

Conclusion

These concepts are fundamental in **computer architecture, programming, and OS design**. Understanding how files are compiled, linked, and executed will help in **C, Java, and system programming**.

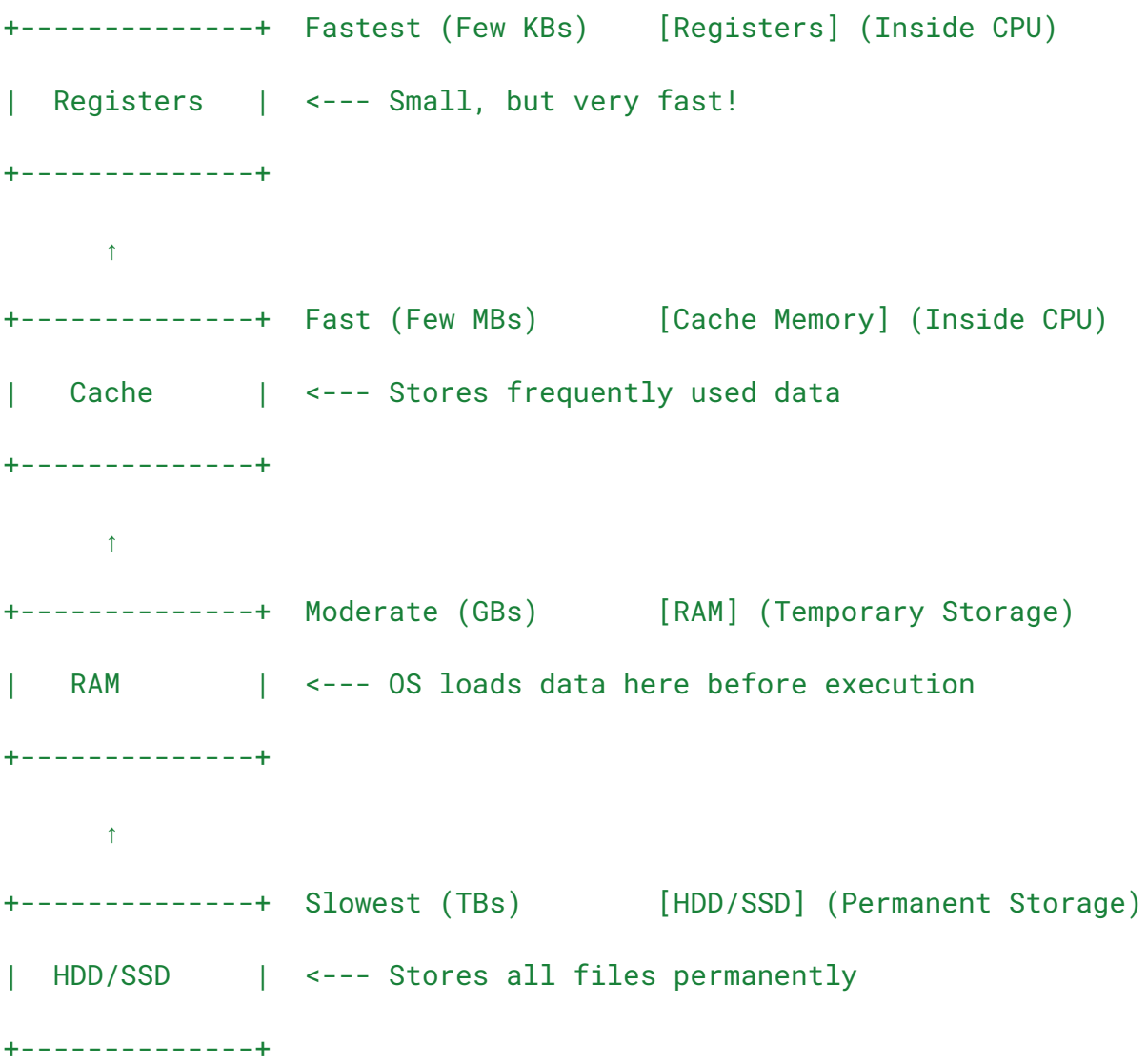
1. Compilation Process (Compiler, Assembler, Linker, Loader)



- Compiler: Converts HLL (C, Java) to Machine Language (.obj file).
- Linker: Links object file with libraries to create an executable (.exe).
- Loader: Loads the executable into RAM for execution.

2. Memory Hierarchy (Register, Cache, RAM, HDD)

📌 **Speed vs. Size**



- **Registers**: Fastest but very small.
- **Cache**: Between RAM & CPU for fast access.
- **RAM**: Temporary memory; lost on shutdown.
- **HDD/SSD**: Permanent storage but slow.

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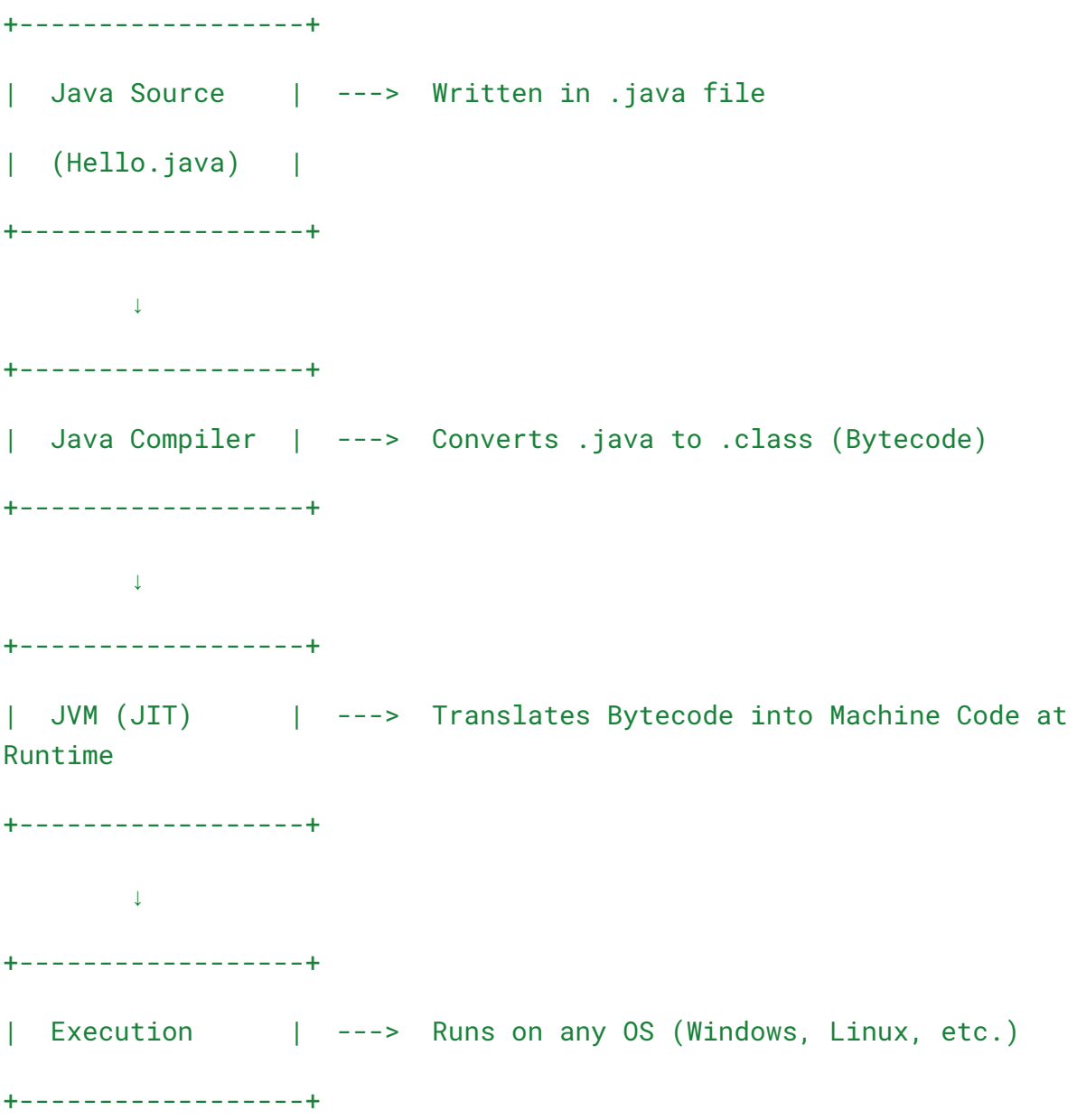
3. Java Execution Flow (JDK, JVM, JIT)

📌 **How Java Code Runs**



- **Java Compiler (javac)**: Converts .java → .class (bytecode).
- **JVM (Java Virtual Machine)**: Executes bytecode on any OS.
- **JIT (Just-In-Time Compiler)**: Optimizes performance by converting frequently used code to native machine code.

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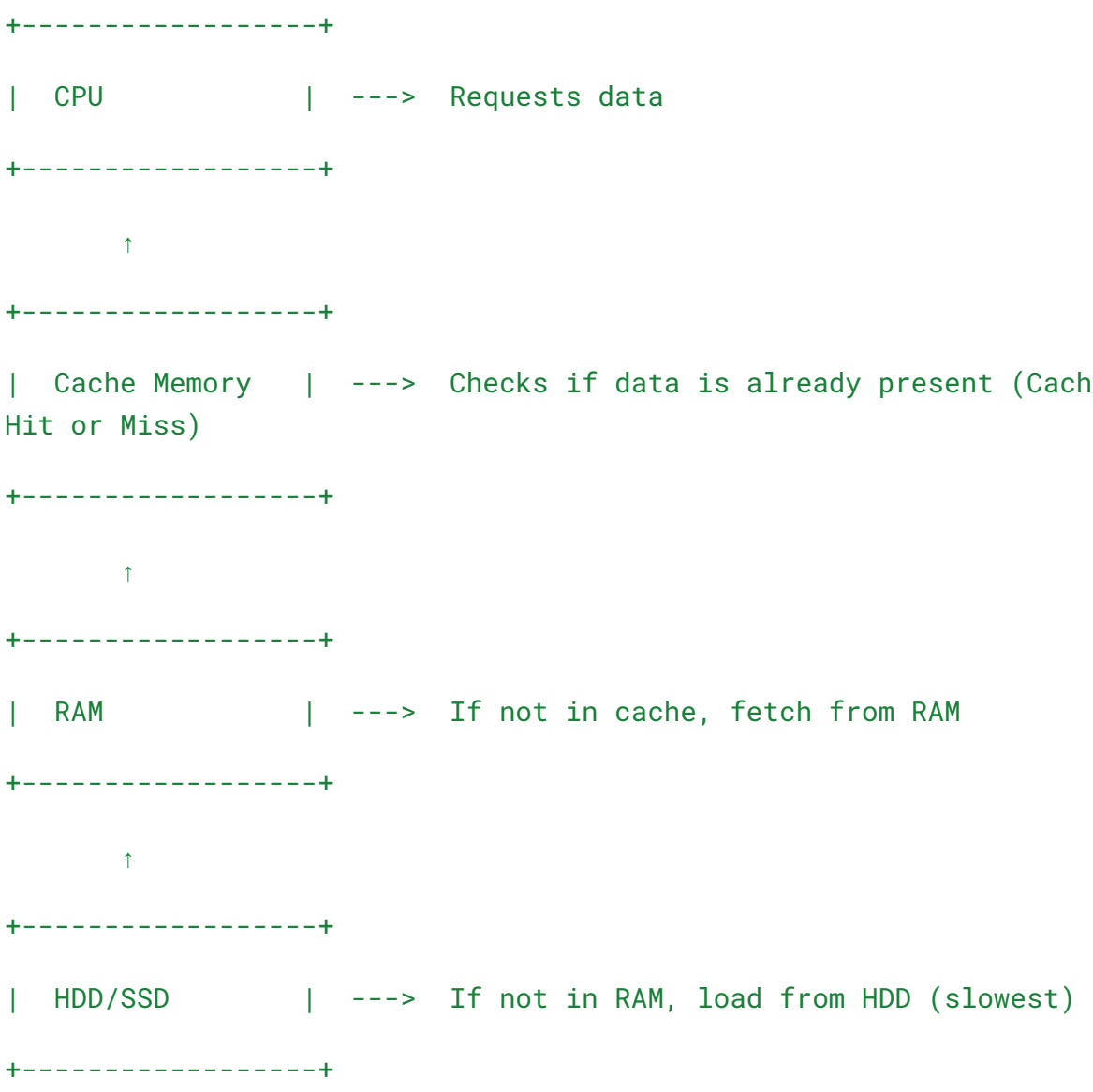
4. Cache Memory Working

📌 How Cache Speeds Up CPU



- **Cache Hit**: If data is in cache → CPU gets it instantly.
- **Cache Miss**: If not in cache → Fetch from RAM/HDD (slower).

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5. File Loading from HDD to RAM

📌 What Happens When You Open a Program

```
        ↓
+------------------+
|  OS (Loader)     |  --->  OS loads the file into RAM
+------------------+
        ↓
+------------------+
|  RAM             |  --->  File is temporarily stored for execution
+------------------+
        ↓
+------------------+
|  CPU Execution   |  --->  CPU processes the data
+------------------+
```

- HDD → RAM → CPU: This is how programs run.
- If **cache is used**, repeated execution is **faster**.

Here's a breakdown of your questions in a structured way:

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1. Difference Between MLL and Bytecode

Feature	Machine Level Language (MLL)	Bytecode
Definition	Code in 0s and 1s that the CPU directly understands	Intermediate code between HLL and MLL
Execution	Directly executed by the processor	Executed by the JVM

Platform Dependency	Platform-dependent	Platform-independent (JVM-dependent)
Generated By	Compiler (C, C++)	Java Compiler (javac)
Example	`101010110011`	`0xCAFEBABE` (Java class file)

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2. What is Architectural Neutral?

- **Concept:** Java follows **"Write Once, Run Anywhere" (WORA)**.
- **Why?** The compiled Java code (.class file) is **not MLL**, but **bytecode**.
- **Execution:** Bytecode runs on JVM, which is available for **Windows, Mac, Linux**.
- **C/C++ Issue:** A compiled C/C++ program (.exe or .out) works only on the platform where it was compiled.

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3. Just-In-Time Compiler (JIT)

- **What is JIT?** Converts bytecode to native machine code **at runtime** to improve performance.
- **How it Works?** Instead of interpreting each line, JIT **compiles frequently used bytecode into MLL** for faster execution.
- **Located In?** Part of the JVM.

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4. Why is JVM Platform Dependent?

- The JVM itself is **compiled separately for each OS** (Windows, Mac, Linux).
- **JVM reads the same .class file** on any platform and converts it into machine-specific instructions.
- **C Language Limitation:** C compiles directly to **machine code (MLL)**, which is **OS-specific**.

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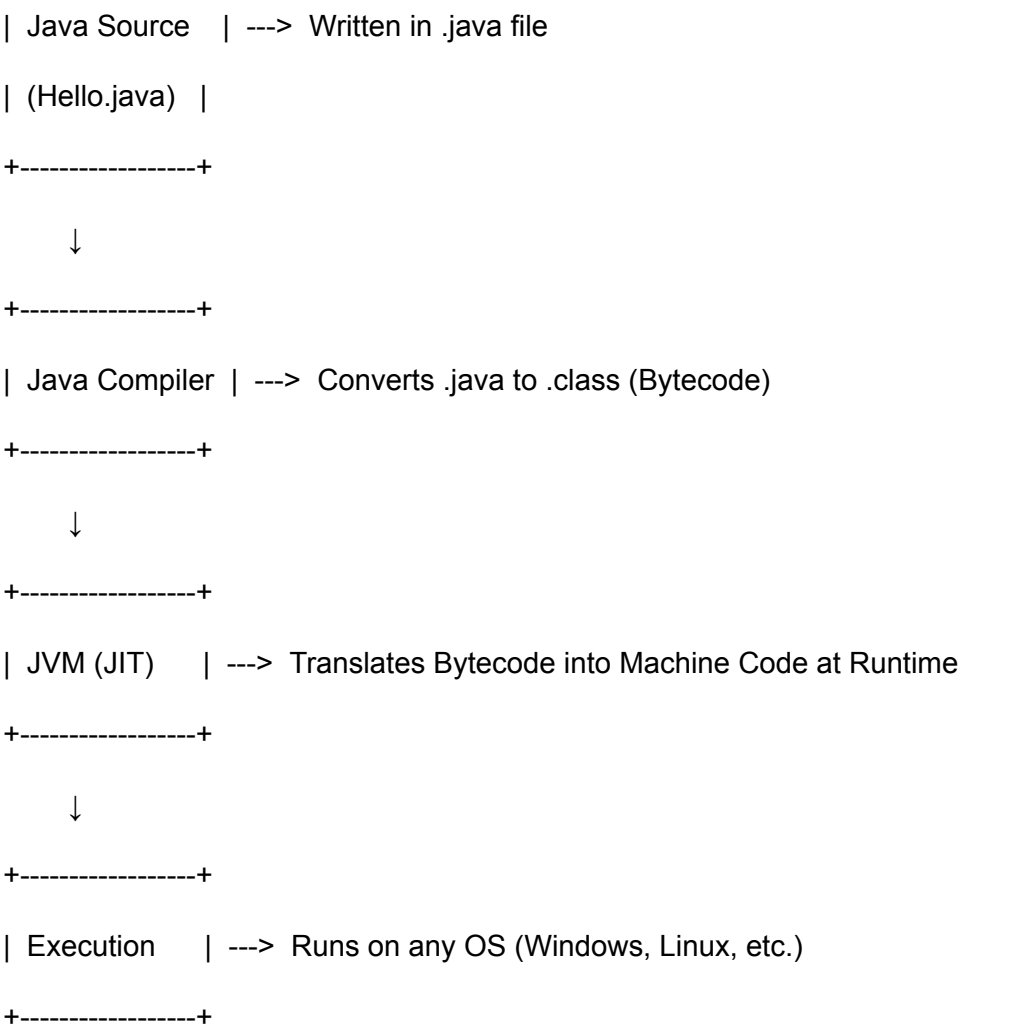
5. Java Compilation and Execution Flow

+-----------------+



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6. JDK vs JRE vs JVM

Component	Contains	Purpose
JDK (Java Development Kit)	JRE + Compiler + Dev tools	Used by Developers to write, compile, and run code
JRE (Java Runtime Environment)	JVM + Libraries	Used by End Users to run Java applications

JVM (Java Virtual Machine)	Class Loader + JIT + GC	Converts bytecode into MLL and executes it

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7. Java LTS Version Updates

- **Java LTS (Long Term Support) versions (8, 11, 17, 21)** do **NOT** auto-update.
- **Manual Update Required:** You must **uninstall the old JDK** and **install the new LTS version**.
- **Recommendation:** Use **JDK 11 or 17** for stability.

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8. What is a JAR File?

- **JAR (Java Archive)**: A **zipped package** containing multiple `.class` files.

Command to Create JAR:
jar cvf myApp.jar *.class

-
- **Why Use?** For bundling applications, libraries, and easier distribution.

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9. Flash Memory

- **Type:** Non-volatile **Read-Only Memory (ROM)**.
- **Used In:** BIOS, USB drives, SSDs.
- **Why Important?** Stores OS boot data, firmware, and critical system files.

Would you like me to add **diagrams** for any of these concepts? 😊