Chapter 02: Computer Organization

Lesson 01:
## Von Neumann Machine Architecture

Objective:

• Understand von Neumann stored program architecture

• Understand alternate architecture─ Harvard Machine architecture

• Understand the meaning of a program

von Neumann machine architecture

Storing of Program and Data in Memory

- A stored program concept is one in which first the program and data are stored in the main memory and then the processor fetches instructions and executes them, one after another

Memory (main) from Address 0 to Address 2^n-1

Data

Program

Data

Program

Processor
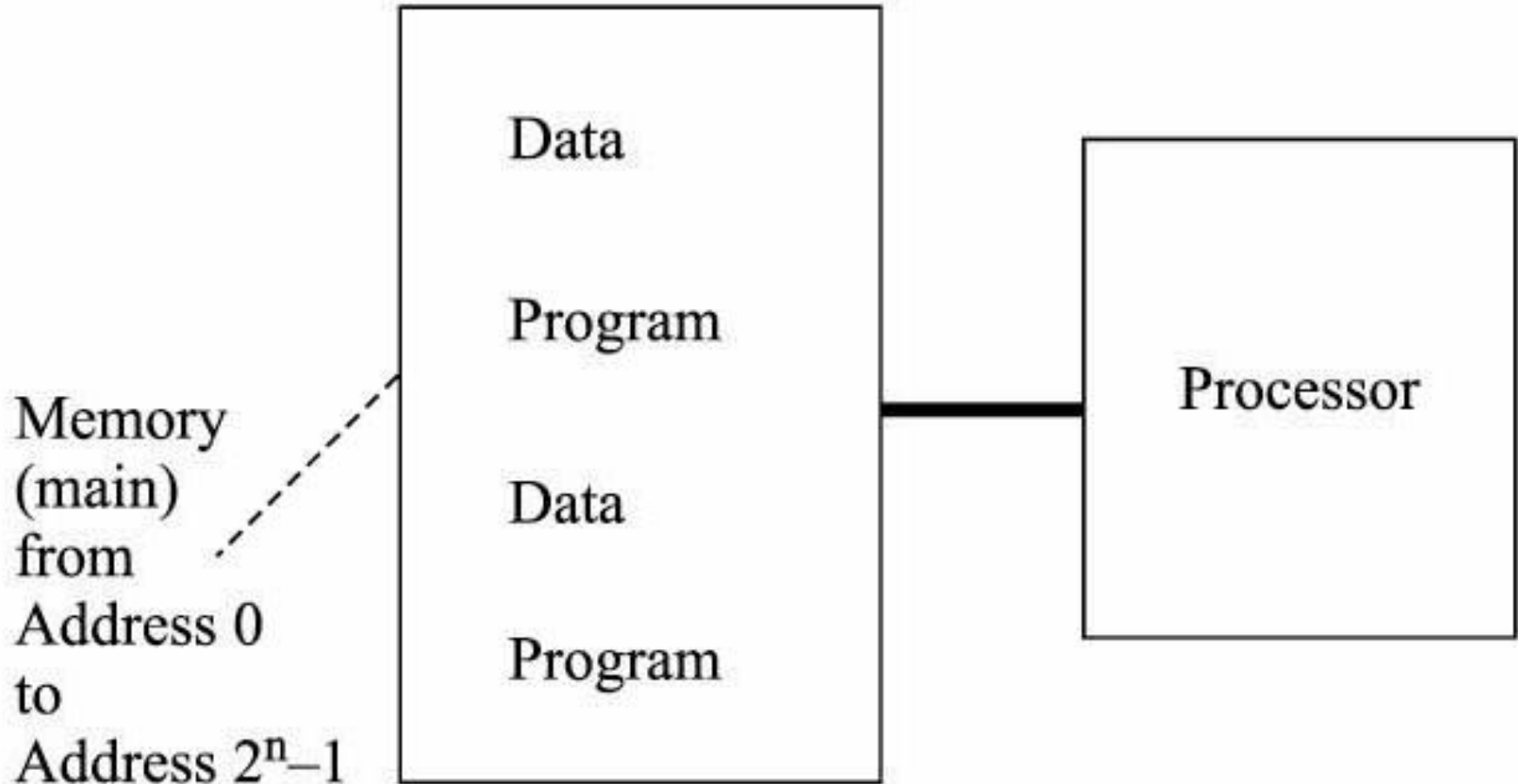
Before Stored-program computer architecture

- Many computers programmed

- Setting the switches or rewiring circuit boards to define the new program

- Required a great deal of time

- Prone to errors

First significant aspect of stored-program computer architecture

- Allows programs to be easily stored and loaded into the machine (processor) from the main memory

- Same set of control signal (s) for the instructions and data fetch

von Neumann's Stored-program computer architecture

- Once a program has been developed and debugged, the numbers that represent its instructions can be written out onto a storage device, allowing the program to be loaded back into (main) memory at some point in the future

Second aspect of the stored-program abstraction

- Perhaps even more significant than first
- Allows programs to treat themselves or other programs as data

Stored-program abstraction

- Second aspect facilitates compilers, debuggers, programming tools designing

Stored-program abstraction as the self-modifying programs

- Programs that treat themselves as data can also function as the self-modifying programs

Use of self-modifying codes

- Have become much less common in more-modern machines

- May not be needed due to the powerful instruction set in the new machines

- Changing the program during execution makes it harder to debug

von Neumann's architecture Self-modifying codes

- Feature not Required

- Computers have become faster

- Ease of program implementation and debugging has become more important than the performance improvements achievable in most earlier programming cases in which self-modifying codes were used

Stored-program computer architecture

- The stored-program abstraction (representing instructions as numbers stored in memory)─ A major breakthrough in early computer architecture
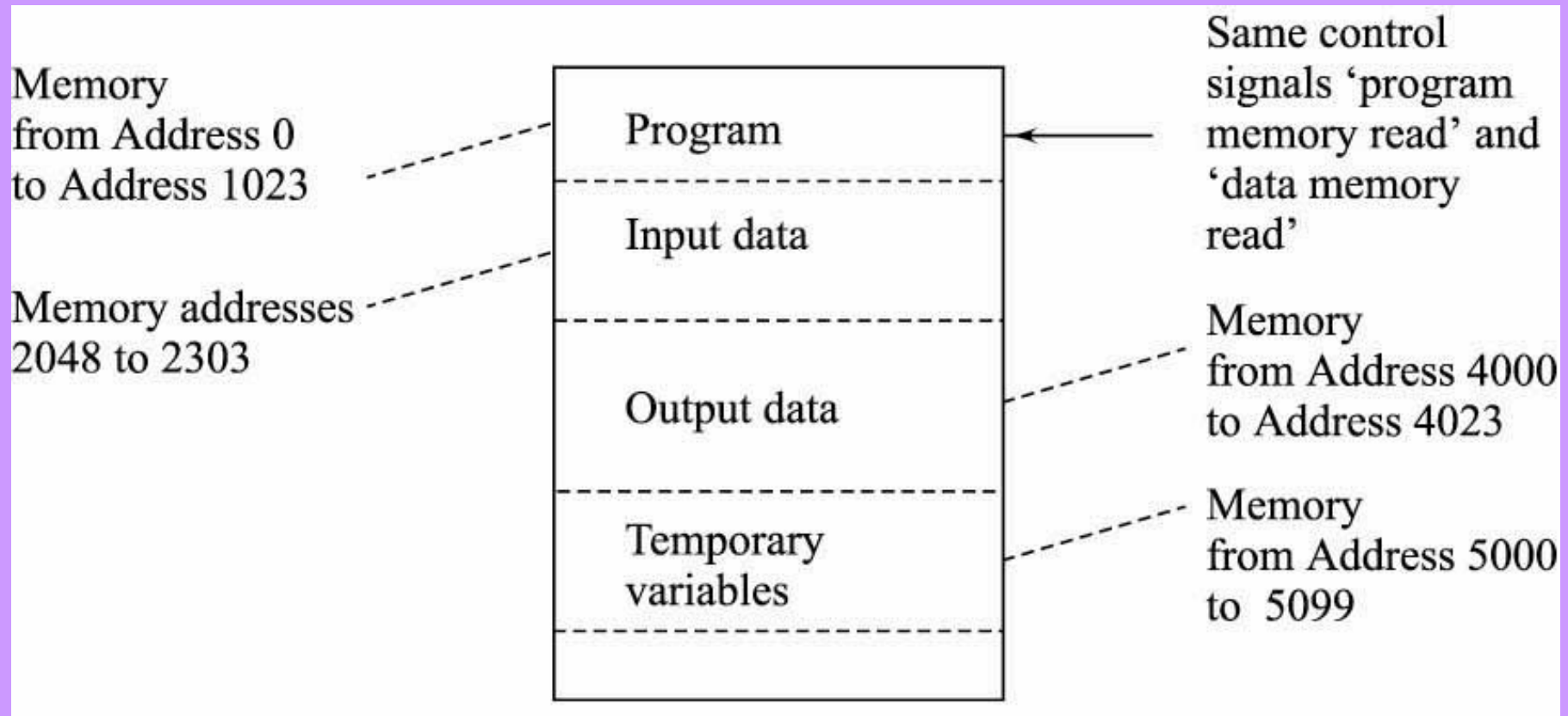
von Neumann Stored-program computer architecture

- Almost most computers in use today ─ *stored-program computers*

- They represent programs as numbers that are stored in the same address space as data in case of von Neumann architecture

von Neumann's stored-program computer memory architecture

- In the program instructions and data are stored in the main memory units without distinguishing these words (bytes) from one another

Example of von Neumann Architecture and addresses for stored program

Memory from Address 0 to Address 1023

Memory addresses 2048 to 2303

Program

Input data

Output data

Temporary variables

Same control signals 'program memory read' and 'data memory read'

Memory from Address 4000 to Address 4023
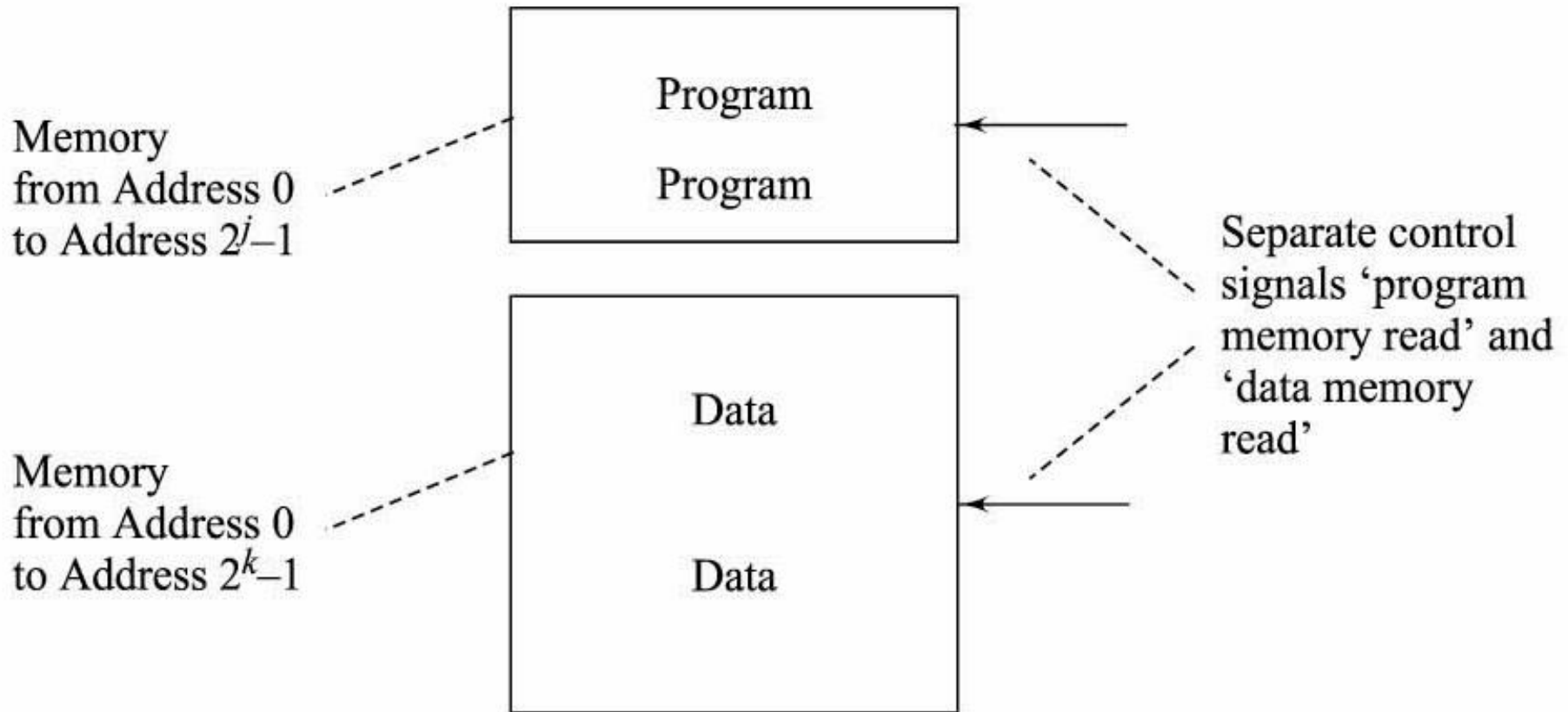
Memory from Address 5000 to 5099

<u>Harvard machine memory architecture</u>

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An aspect of Harvard Machine architecture

- Allows programs to be separately stored and loaded into the machine (processor) from the program memory and data from data memory
- The set of control signal (s) different for the instructions and data fetches

Harvard Architecture for stored programs

Memory from Address 0 to Address 2^j-1

Program

Program

Memory from Address 0 to Address 2^k-1

Data

Data

Separate control signals 'program memory read' and 'data memory read'

Few aspects of Harvard Machine architecture

- Enables single instruction operating on multiple data (SIMD)

- Allows programs to be separately stored and loaded into the machine (processor) from the read only program memory while data from data read and write memory

- The set of control signal (s) different for the instructions and data fetches

Meaning of a Program

Meaning of Program

- Programmer's view─ sequences of instructions that tell the computer what operations to do

- The computer's view of the instructions that make up a given program─ often very different from the program writer's view

Meaning of Program to the computer

- Program made up of a sequence of numbers that represent individual operations.

- These operations known as *machine instructions* or just *instructions*

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Meaning of Instruction Set

- The set of operations that a given processor can execute

Programmer's view

- Program — $y = i * * 4$

Computer's view it as <u>MACHINE INSTRUCTIONS</u>

- Assume Program — y = i * * 4

(i) Move *bits* from address of *i* into *A* register
   [A ≡ i]

(ii) Move A register into B register [B ≡ i]

Meaning of Program

(iii) Multiple A register * B register and put result in A itself [A ≡ i^2]

(iv) Multiple A register * B register [A ≡ i^3]

(v) Multiple A register * B register [A ≡ i^4]

(vi) Put the result at the address of y [y ≡ i^4]

Summary

We learnt

- Stored program concept─ store instruction and data in main memory before execution

- von Neumann stored-program architecture stores instruction and data in main memory without distinguishing them from one another

- Store instruction and data in main memory at the same address space

We learnt

- Harvard architecture program stores instruction and data in different memory with distinguishing them from one another

- Store instruction and data in different memory at the different address spaces

We learnt

- Meaning of Program To the programmer
- Meaning of Program To the computer

End of Lesson 01

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Von Neumann Machine Architecture