Computer Organization & Assembly Language

(Lecture 02)

Omar Bin Samin

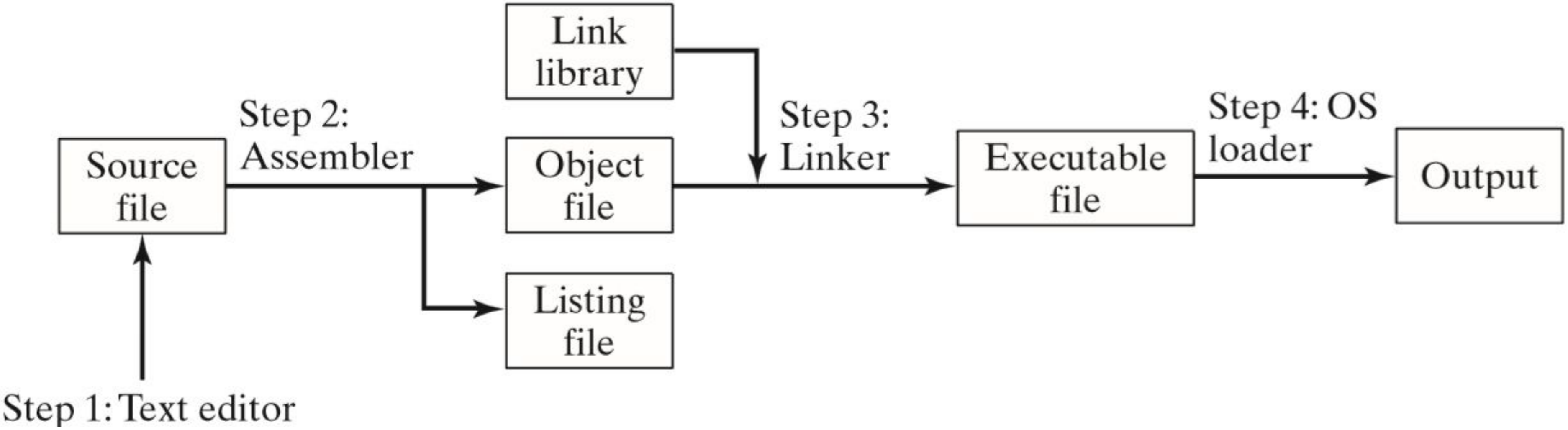
Lecturer

Institute of Management Sciences, Peshawar.

Assembling, Linking and Running Programs

- A source program written in assembly language cannot be executed directly on its target computer
- It must be translated, or assembled into an executable code
- The assembler produces a file containing machine language called an **object file**
- This file isn't quite ready to execute. It must be passed to another program called a **linker**, which in turn produces an executable file

Assembly Link Execute Cycle



- **Step 1:**
  - A programmer uses a text editor to create a text file named source file using assembly language

- **Step 2:**
  - The assembler reads the source file and produces an object file (a machine-language translation of the program)
  - Optionally, it produces a listing file (it contains a copy of the program's source code, suitable for printing with line numbers, offset addresses and translated machine code)
  - If any error occurs, the programmer must return to Step 1 and fix the program

- **Step 3:**
  - The linker reads the object file and checks to see if the program contains any calls to procedures in a link library
  - The linker copies any required procedures from the link library, combines them with the object file and produces an executable file

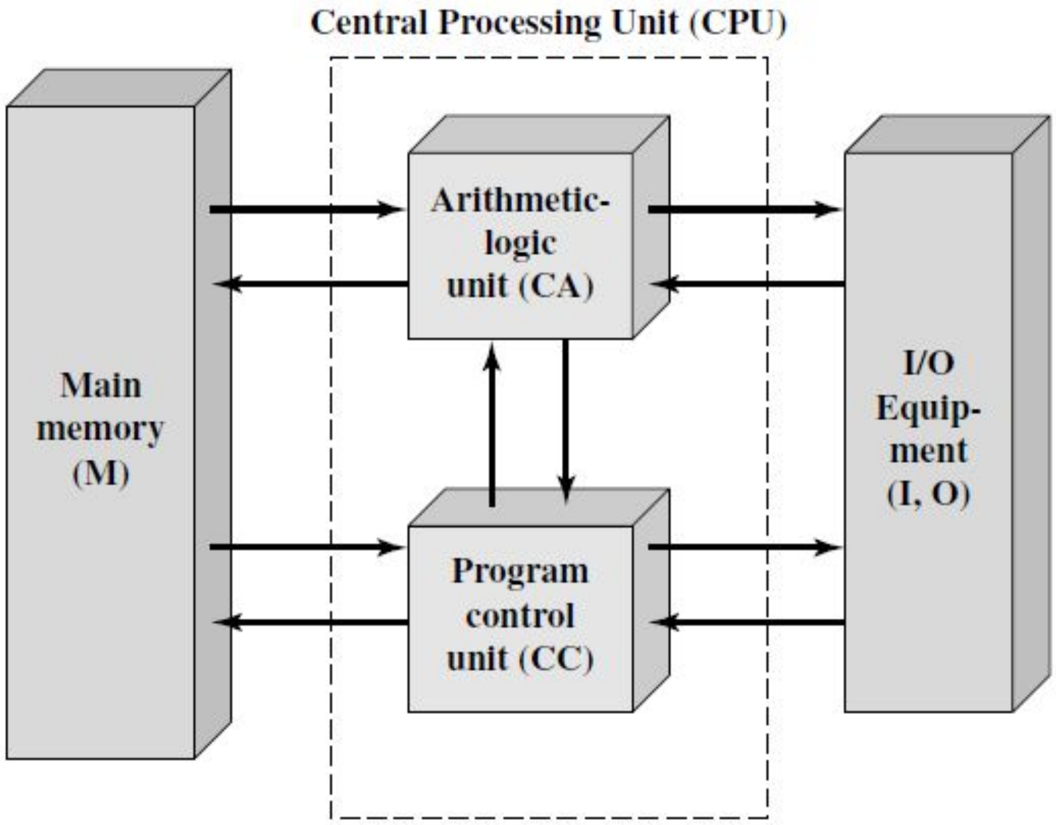
- **Step 4:**
  - The operating system loader utility reads the executable file into memory and branches the CPU to the program's starting address and the program begins to execute

The Von Neumann Machine

- In 1946, von Neumann and his colleagues began the design of a new stored program computer, referred to as the Institute for Advanced Study (IAS) computer

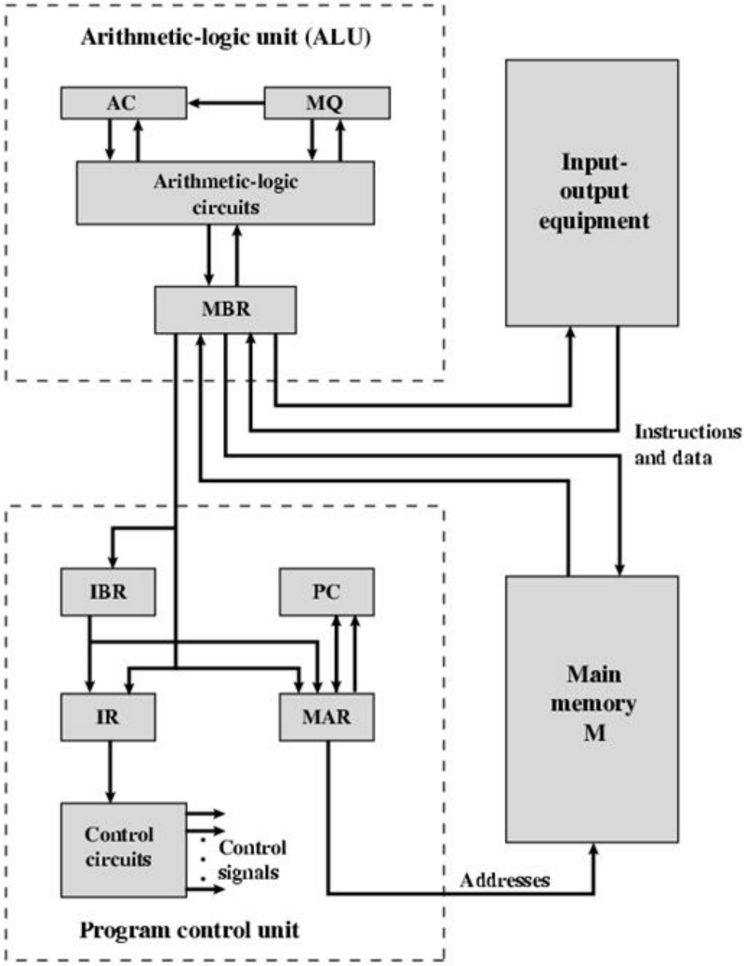
- It was able to store program in memory alongside the data. This idea is known as “Stored Program Concept”

Structure of IAS Computer


Central Processing Unit (CPU)
Main memory (M)
Arithmetic-logic unit (CA)
Program control unit (CC)
I/O Equip-ment (I, O)

- IAS computer consists of:
  - A main memory, which stores both data and instructions
  - An Arithmetic Logic Unit (ALU) capable of operating on binary data
  - A Control Unit, which interprets the instructions in memory and causes them to be executed
  - Input and Output (I/O) equipment operated by the control unit

Expanded Structure of IAS Computer



- The above figure reveals that both the control unit and the ALU contain storage locations, called ***registers***, *discussed as follows:*
  - **Memory Buffer Register (MBR):** contains a word to be stored in memory or sent to the I/O unit, or is used to receive a word from memory or from the I/O unit
  - **Memory Address Register (MAR):** specifies the address in memory, of the word to be written from or read into the MBR

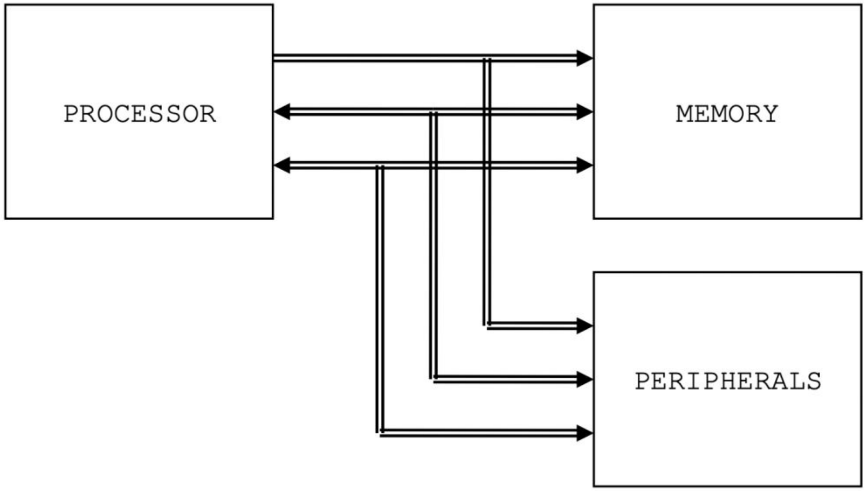
- **Program Counter (PC):** contains the address of the next instruction pair to be fetched from memory

- **Accumulator (AC) and Multiplier Quotient (MQ):** employed to hold temporarily operands and results of ALU operations. For example, the result of multiplying two 64-bit numbers is 128-bit number; the most significant 64-bits are stored in the AC and the least significant 64-bits in the MQ

- **Instruction Register (IR):** contains the 8-bit opcode instruction being executed

- **Instruction Buffer Register (IBR):** employed to temporarily hold the instruction from a word in memory

Basic Computer’s Structure



- There are four main structural components:

1. Central Processing Unit (CPU): Controls the operation of the computer and performs its data processing functions; often simply referred to as a processor

2. Main Memory: Stores data (Volatile)

3. Peripherals/ I/O: Moves data between the computer and its external environment

4. System Interconnection: Some mechanism that provides for communication among CPU, main memory and I/O

- A common example of system interconnection is by means of a system bus, consisting of number of conducting wires to which all the other components are attached

CPU

- Major structural components of CPU are as follows:
  - Control Unit: Controls the operation of the CPU and hence the computer
  - Arithmetic Logic Unit (ALU): Performs the computer’s data processing functions
  - Registers: Provides internal storage to the CPU
  - CPU Interconnection: Provides mechanism for communication among the control unit, ALU and registers

Main Memory

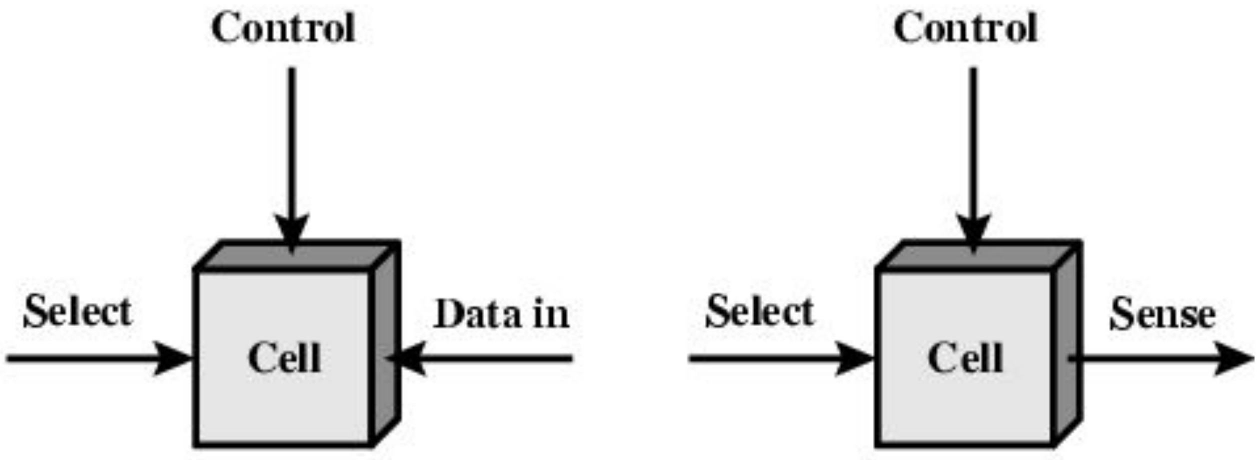
- Storage cell unit consist of **N** cells, each of which can store 1 bit (either ‘0’ or ‘1’)

- Can perform read/ write both operations

- Volatile

Memory Cell Operation

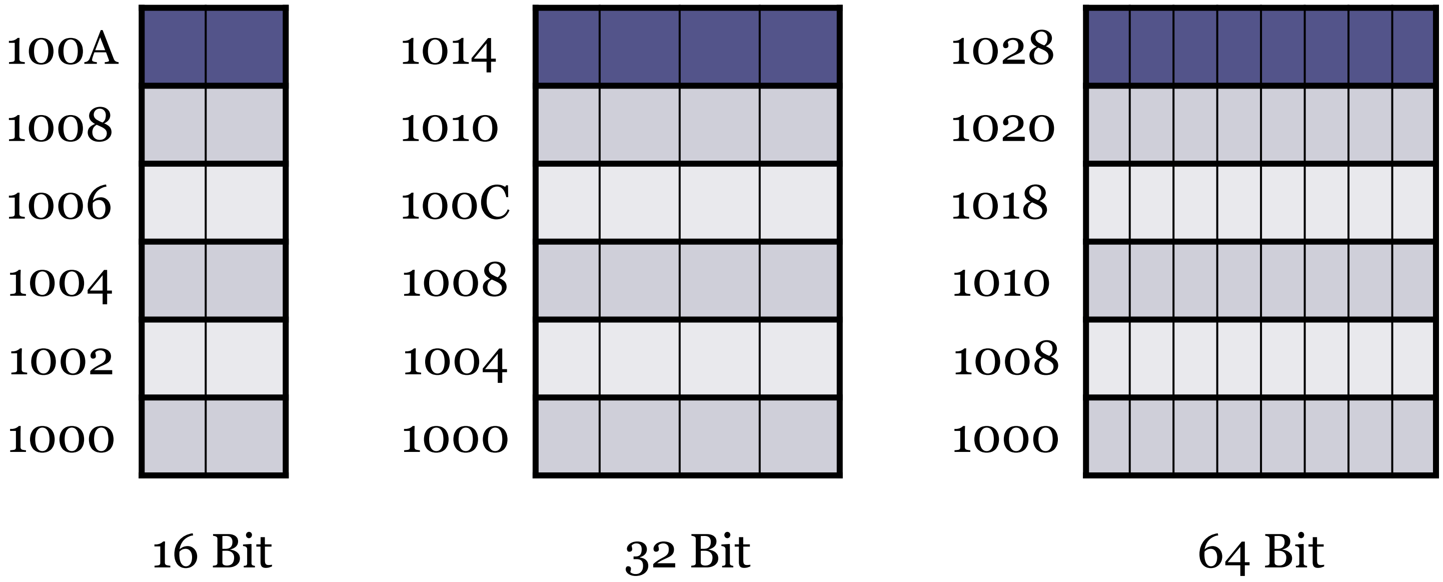
- The cell has three functional terminals, capable of carrying an electrical signal



(a) Write (b) Read

- Select Terminal
  - As the name suggests, selects a memory cell for a read or write operation
- Control Terminal
  - Indicates the required operation (read or write)
- Data In/ Sense Terminal
  - For writing, this terminal provides an electrical signal that sets the state of the cell to ‘0’ or ‘1’
  - For reading, this terminal is used for output of the cell’s state

Main Memory Logical Structure



100A
1008
1006
1004
1002
1000

16 Bit

1014
1010
100C
1008
1004
1000

32 Bit

1028
1020
1018
1010
1008
1000

64 Bit

System Interconnections: Bus

- A bus is a communication pathway, connecting two or more devices

- Typically, a bus consists of multiple communication pathways or lines

- Each line is capable of transmitting signals representing binary ‘1’ and binary ‘0’

- Over time, a sequence of binary digits can be transmitted across a single line

- Taken together, several lines of a bus can be used to transmit binary digits simultaneously (in parallel)

- Example
  - An 8-bit unit of data can be transmitted over eight bus lines simultaneously

Bus Line Classifications

- Bus lines can be classified as three functional groups:

1. Data or I/O Bus
2. Control Bus
3. Address Bus

Data or I/O Bus

- This contains the content that have been read from the memory location or is to be written into the memory location

- It is bidirectional, as CPU requires to send and receive the data

- The word length of a CPU depends on data bus, that's why Intel 8086 is called 16-bit microprocessor because it has 16-bit data bus

Control Bus

- The control bus is used for sending control signals (typically read or write) to the memory and I/O devices

- The CPU sends control signals on the control bus to enable the outputs of addressed memory devices or I/O port devices

- It is unidirectional

Address Bus

- CPU uses address bus to send out the address of the memory location

- The address bus carries the address of memory location to be written or to be read from

- It is unidirectional, as bits flowing occurs only in one direction

- Basic 8086 consists of 20-bit address bus

- The memory locations that a microprocessor can access can be calculated as:

  2^N (where N is the number of bits used for address lines)

  2^20 = 1,048,576 bytes or 1 Mb

- So it can access up to 1 Mb memory locations

Computer Functions

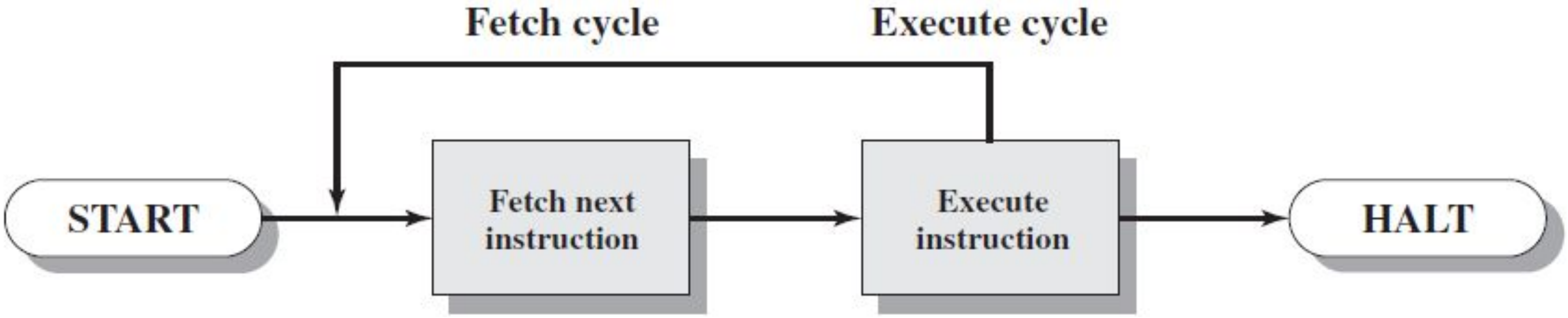
- The basic function performed by a computer is execution of a program, which consists of a set of instructions stored in memory
- The processor does the actual work by executing instructions specified in the program
- Instruction processing consists of two steps:
  - Fetch instruction - fetch cycle
  - Execute instruction - execute cycle

- The processor reads (fetches) instructions from memory one at a time and executes each instruction

- Program execution consists of repeating the process of instruction fetch and instruction execution

- The instruction execution may involve several operations and depends on the nature of the instruction

- The processing required for a single instruction is called an **instruction cycle**

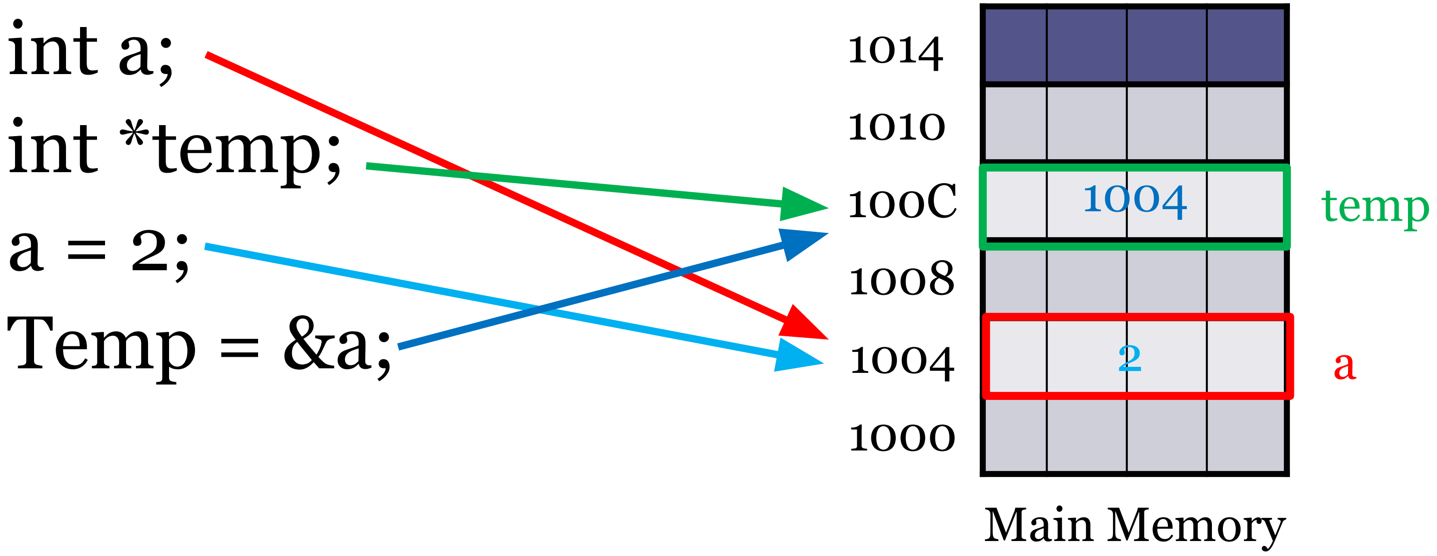


Basic Instruction Cycle

Program execution halts only if the machine is turned off, or some sort of unrecoverable error occurs, or a program instruction that halts the computer is encountered

Program to Main Memory Mapping

- Consider the following piece of main memory and code:



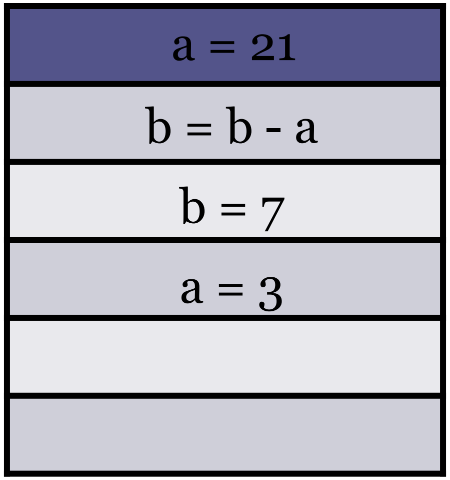
```
int a;
int *temp;
a = 2;
Temp = &a;
```

1014		
1010		
100C	1004	temp
1008		
1004	2	a
1000		

Main Memory

Question?

- What will be the final value of ‘a’, that is stored in Main Memory?



a = 21

b = b - a

b = 7

a = 3

Main Memory