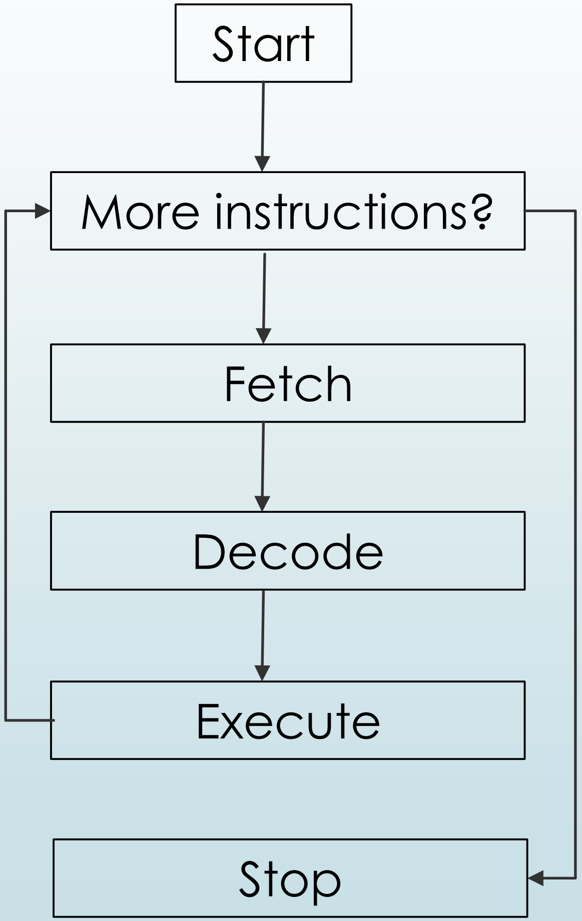
Program execution

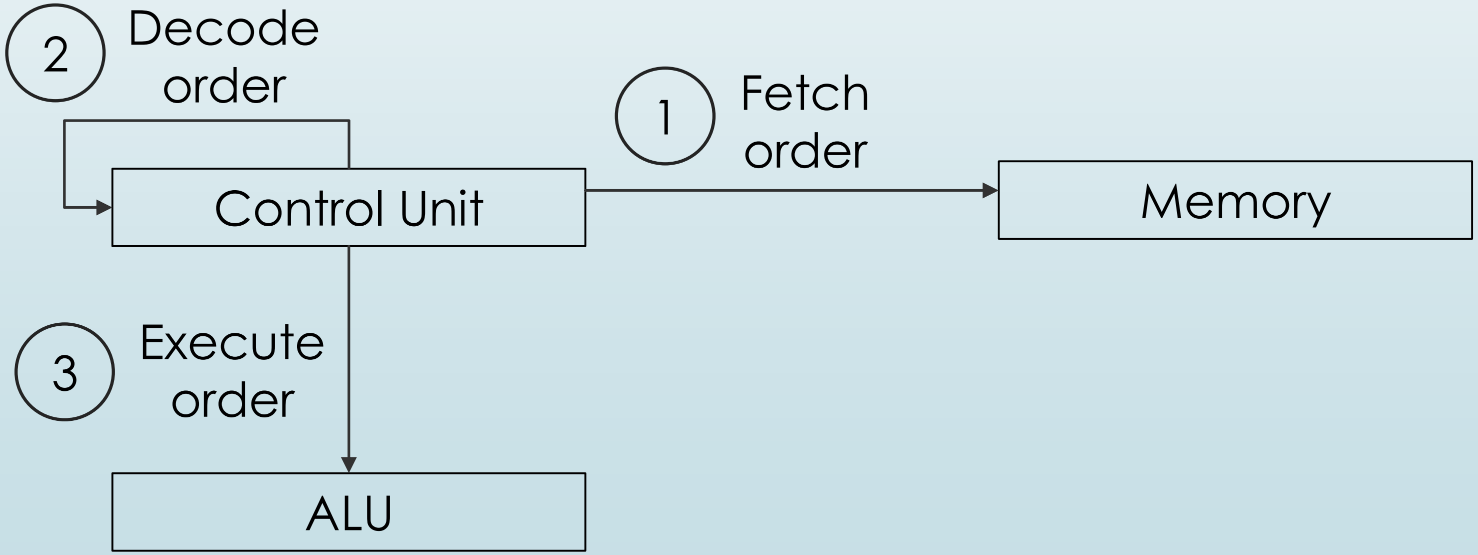
How the CPU executes program instructions ?



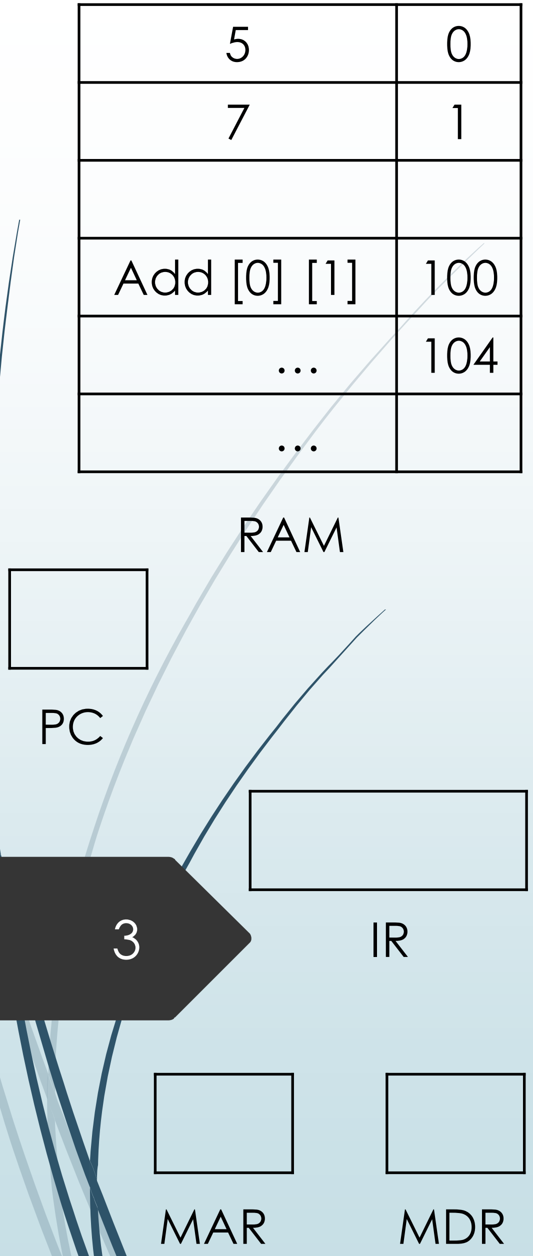
Machine cycle

Machine Cycle:

- Instruction time: Fetch, Decode
- Execution time: Execute



Instruction execution



5	0
7	1
Add [0] [1]	100
…	104
…	

RAM

Several types of registers are used to execute an instruction:

Program Counter (PC): contains the address of the next instruction to be executed.

Memory Address Register (MAR): contains the address to be read or written.

Memory Data Register (MDR): contains both instructions and data.

Instruction Register (IR): contains the current instruction being executed.

ALU Input/Output registers: AX, BX, AC

Fetch

Consider the 1-address machine with 3 operations: load, add and store.

1) Fetch an instruction:

The address of the next instruction to be fetched is in PC.

MAR ← PC

Control Unit $\xrightarrow[\text{Control bus}]{\text{Read}}$ Memory

Control Unit $\xrightarrow[\text{Address bus}]{\text{MAR}}$ Memory

MDR $\xleftarrow[\text{Data bus}]{\text{Information}}$ Memory

IR ← MDR

Decode

2) Decode an instruction:

PC ← PC +1

IR Opcode	IR Operand

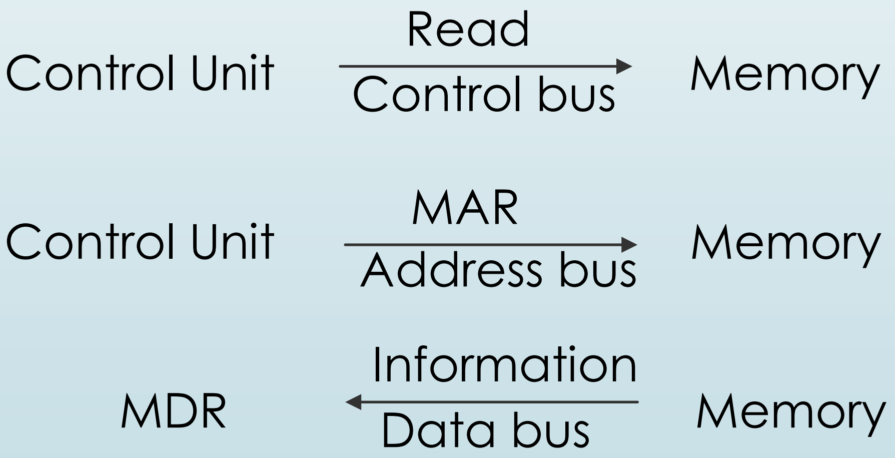
Execute (1)

3) Execute an instruction:

The address of the next instruction to be fetched is in PC.

MAR ← IR Operand

Case 1: Opcode=Load



Control Unit $\xrightarrow[\text{Control bus}]{\text{Read}}$ Memory

Control Unit $\xrightarrow[\text{Address bus}]{\text{MAR}}$ Memory

MDR $\xleftarrow[\text{Data bus}]{\text{Information}}$ Memory

AC ← MDR

Execute (2)

Case 2: Opcode=Add

AX ← AC

$$\text{Control Unit} \xrightarrow[\text{Control bus}]{\text{Read}} \text{Memory}$$

$$\text{Control Unit} \xrightarrow[\text{Address bus}]{\text{MAR}} \text{Memory}$$

$$\text{MDR} \xleftarrow[\text{Data bus}]{\text{Information}} \text{Memory}$$

BX ← MDR

$$\text{Control Unit} \xrightarrow[\text{Control bus}]{\text{Add}} \text{ALU}$$

$$\text{AC} \xleftarrow[\text{Data bus}]{\text{Result}} \text{ALU}$$

Execute (3)

Case 3: Opcode=Store

$$\text{Control Unit} \xrightarrow[\text{Control bus}]{\text{Write}} \text{Memory}$$

$$\text{Control Unit} \xrightarrow[\text{Address bus}]{\text{MAR}} \text{Memory}$$

MDR ← AC

$$\text{Control Unit} \xrightarrow[\text{Data bus}]{\text{MDR}} \text{Memory}$$

Exercice

Given a high-level language code:

z=x+y

converted into the following assembly code:

Load [10]

Add[11]

Store[12]

where x has the address 10, y:11 and z:12.

2	10
3	11
	12
Load [10]	100
Add [11]	101
Store [12]	102

Show fetch, decode and execute steps of each of these instructions using PC, IR, MAR, MDR, AX, BX and AC.