Topic for today:

Still more on instructions and Instruction Set Architecture (ISA)

Recall

The MARIE instruction set has a *1-address* format. That means:

- A typical instruction contains an opcode and the address of an operand
- For binary operations, the location of the second operand and the destination of the result are both assumed to be the *accumulator*

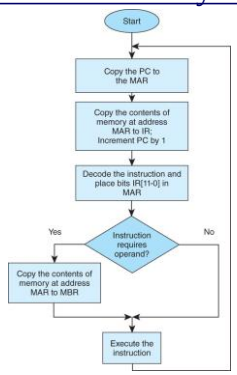
Fetch-Decode-Execute cycle

The basic cycle of the CPU is:

- **Fetch** the next instruction from the memory location specified by the Program Counter (PC) into the Instruction Register (IR); increment the PC
- **Decode** the instruction's opcode
- **Execute** the instruction

This process repeats continuously.

Fetch-Decode-Execute cycle



Hex Address	Instruction	Binary Contents of Memory Address	Hex Contents of Memory
100	Load 104	0001000100000100	1104
101	Add 105	0011000100000101	3105
102	Store 106	0010000100000110	2106
103	Halt	0111000000000000	7000
104	0023	0000000000100011	0023
105	FFE9	1111111111101001	FFE9
106	0000	0000000000000000	0000

Hex Address	Instruction
100	Load 104
101	Add 105
102	Store 106
103	Halt
104	0023
105	FFE9
106	0000

a) Load 104

Step	RTN	PC	IR	MAR	MBR	AC
(initial values)		100	------	------	------	------
Fetch	MAR ← PC	100	------	100	------	------
	IR ← M[MAR]	100	1104	100	------	------
	PC ← PC + 1	101	1104	100	------	------
Decode	MAR ← IR[11-0]	101	1104	104	------	------
	(Decode IR[15-12])	101	1104	104	------	------
Get operand	MBR ← M[MAR]	101	1104	104	0023	------
Execute	AC ← MBR	101	1104	104	0023	0023

b) Add 105

Step	RTN	PC	IR	MAR	MBR	AC
(initial values)		101	1104	104	0023	0023
Fetch	MAR ← PC	101	1104	101	0023	0023
	IR ← M[MAR]	101	3105	101	0023	0023
	PC ← PC + 1	102	3105	101	0023	0023
Decode	MAR ← IR[11-0]	102	3105	105	0023	0023
	(Decode IR[15-12])	102	3105	105	0023	0023
Get operand	MBR ← M[MAR]	102	3105	105	FFE9	0023
Execute	AC ← AC + MBR	102	3105	105	FFE9	000C

c) Store 106

Step	RTN	PC	IR	MAR	MBR	AC
(initial values)		102	3105	105	FFE9	000C
Fetch	MAR ← PC	102	3105	102	FFE9	000C
	IR ← M[MAR]	102	2106	102	FFE9	000C
	PC ← PC + 1	103	2106	102	FFE9	000C
Decode	MAR ← IR[11-0]	103	2106	106	FFE9	000C
	(Decode IR[15-12])	103	2106	106	FFE9	000C
Get operand	(not necessary)	103	2106	106	FFE9	000C
Execute	MBR ← AC	103	2106	106	000C	000C
	M[MAR] ← MBR	103	2106	106	000C	000C

Practice problems

1. Add the number at address 3D0 to the number at 3D1, and store the result at 3D2.

2. If the number at 6A4 is greater than the number at 6A5, jump to the instruction at 059. Otherwise, jump to the instruction at 098.

Machine Language

Machine language for a particular ISA is the programming language that consists of the instructions written in binary.

It is the only programming language that the CPU can execute directly.