ICS 2022 Problem Sheet #10

Problem 10.1: assembler programming

The following program has been written for the simple central processing unit introduced in class. The table below shows the initial content of the 16 memory cells. The first column denotes the memory address and the second column shows the memory content in hexadecimal notation.

Cell	Hex	Binary	Assembler	Description
0	2f	001 0 1111	LOAD 15	Load the value of memory location 15 into the accumulator
1	6a	011 0 1010	ADD 10	Add the value of memory location 10 to the accumulator
2	4f	010 0 1111	STORE 15	Store the value of the accumulator in memory location 15
3	21	001 0 0001	LOAD 1	Load the value of memory location 1 into the accumulator
4	71	011 1 0001	ADD #1	Add the value 1 to the accumulator
5	41	010 0 0001	STORE 1	Store the value of the accumulator in memory location 1
6	a9	101 0 1001	EQUAL 9	Skip instruction if accumulator equal to memory location 9
7	d0	110 1 0000	JUMP #0	Jump to instruction 0 (set program counter to 0)
8	e0	111 0 0000	HALT	Stop execution
9	6f	011 0 1111	ADD 15	Add the value of memory location 15 to the accumulator
10	01	000 0 0001		
11	02	000 0 0010		
12	03	000 0 0011		
13	04	000 0 0100		
14	05	000 0 0101		
15	06	000 0 0110		

a) Convert the machine code from hexadecimal notation into binary notation.

b) Write down the assembler code for the machine code. Add meaningful descriptions.

c) The program leaves a result in memory cell 15 when it halts. What is the value? Explain how the program works.

After it halts the program leaves the result 21 in memory cell 15, because it loops 5 times and adds something every time, so 6 (the original value stored in memory cell 15) + 1(the value stored in memory cell 10) + 2(the value stored in memory cell 11) + 3(the value stored in memory cell 12) + 4(the value stored in memory cell 13) + 5(the value stored in memory cell 14) = 21.

The program works at it follows: it will increase the value of memory location 1, originally 6a, with 1 every time it loops until it will be equal with the value of memory location 9, that is 6f, so the program will loop 5 times, while it will also add the values in memory cells 10,11,12,13 and 14 (as the value from memory cell 1 increases, from 6a to 6f) to the value in memory cell 15.

d) What happens if the value stored in memory cell 9 is changed to 0x70 before execution starts? Explain.

It the value stored in memory cell 9 is changed to 0x70 before execution starts it means that the value in the memory location 1 will have to increase to 70 instead of 6f, so one more time, so the program will loop one additional time, so the value in memory cell 15 will also increase one more time, meaning that the program would leave the result 42 instead of 21 in memory cell 15, as it will also add the value stored in its memory cell.