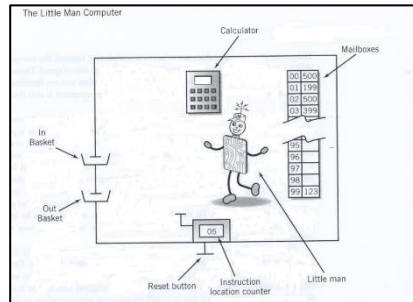


Chapter 6 The Little Man Computer

Consider this model of the LMC and answer the questions below.



Discussion Questions

Please refer to this table of op codes for the discussion questions

Opcode	Definition
0	Halt
1	ADD
2	SUBTRACT
3	STORE
5	LOAD
6	BRANCH UNCONDITIONALLY
7	BRANCH ON ZERO
8	BRANCH ON POSITIVE
901	INPUT
902	OUTPUT

1) Using the LMC program below, add comments to explain what the result (value in the calculator) is after the completion of each instruction. The first one is completed as an example.

Mailbox	Contents	Result after completion
00	901	<i>Read contents from in basket and store in calculator</i>
01	319	
02	901	
03	320	
04	219	
05	709	
06	518	
07	902	
08	000	
09	517	
10	902	
11	000	

```

-----
17    DAT
18    DAT
19    DAT
20    DAT

```

Sol:

Mailbox	Contents	Result after completion
00	901	Read contents from in basket and store in calculator
01	319	Reads contents from calculator and copies it to address (19)
02	901	Reads contents from basket and stores in calculator
03	320	Reads contents from calculator and copies it to address (20)
04	219	Subtracts address (19)'s value from value in calculator
05	709	If calculator is 0, change instruction counter to (09), else move on
06	518	Takes value from adress (18) and inputs into calculator
07	902	Takes the value from calculator and gives to out basket
08	000	Program complete. Rest
09	517	Takes value from address (17) and inputs into calculator
10	902	Takes the value from calculator and gives to out basket
11	000	Program complete. Rest

17	DAT	
18	DAT	
19	DAT	
20	DAT	

Section 6.2 Operation of the LMC

Section 6.4 An Extended Instruction Set

2) Refer to the LMC program in question (1). Suppose the contents of mailbox 17 = 5; contents of mailbox 18 = 1.

- What is the final value in outbasket if the first in basket is 56 and second in basket is 89?
- What is the final value in outbasket if the first in basket is 75 and second in basket is 75?
- What is the final value in outbasket if the first in basket is 89 and second in basket is 56?

Sol: The order of input does not matter.

- 1
- 5
- 1

Section 6.2 Operation of the LMC

Section 6.4 An Extended Instruction Set

3) Describe what the LMC program in question (1) does. Suppose the contents of mailbox 17 = 5; contents of mailbox 18 = 1.

Sol: The LMC program question (1) depicts a program which accept two numbers, subtracts one from the other, and if the answer is 0, the program gives the contents of mailbox 17. If the answer is not 0, the program outputs the value from mailbox 18.

Suppose the contents of mailbox 17 = 5; contents of mailbox 18 = 1. This means that if the difference of the two inputed numbers is 0, the output is 5. If the difference is not 0, the output is 1.

Section 6.2 Operation of the LMC

Section 6.4 An Extended Instruction Set

4) Refer to the LMC program below and the table of op codes given above.

a) What is the first number placed in the outbasket?

b) What is the last number placed in the outbasket?

Mailbox	Contents	
00	517	Takes address(17) and inputs in calculator
01	218	Subtracts address (18) value from claculator
02	902	Reads value from calculator and gives to out basket
03	705	If calculator value is 0 go to address 05. Else move on
04	601	Go to address (01)
05	000	Program is complete. Rest
.....		
17	100	DAT
18	2	DAT

Sol:

a) 98

b) 0

Section 6.2 Operation of the LMC

Section 6.4 An Extended Instruction Set

5) Refer to the LMC program in question (4). Change DAT in mailbox 18 to 4.

a) What is the first number placed in the out basket?

b) What is the last number placed in the out basket?

Sol:

a) 96

b) 0

Section 6.2 Operation of the LMC

Section 6.4 An Extended Instruction Set

6) Describe what the LMC program in question (4) does.

Sol: The LMC program stores the value 100 in mailbox 17 and the value 2 in mailbox 18. It subtracts 2 from 100 and outputs the result. If the difference is 0, the program halts. If the answer is not 0, the program loops back and subtracts the value of mailbox 18 – value 2 – again. This process repeats until the answer is 0 and the program halts.

Section 6.2 Operation of the LMC

Section 6.4 An Extended Instruction Set

7) Refer to the LMC program below. Writedown what the calculator will hold after the instruction is complete in each loop. The first one is completed as an example.

Mailbox	Contents	Calculator after instruction is complete			
		Loop1	Loop2	Loop3	Loop4
00	517	1	2	3	4
01	118				
02	317				
03	219				
04	710				
05	600				
.....					
17	1	DAT			
18	1	DAT			
19	5	DAT			

Sol:

Mailbox	Contents	Calculator after instruction is complete			
		Loop1	Loop2	Loop3	Loop4
00	517	1	2	3	4
01	118	2	3	4	5
02	317	2	3	4	5
03	219	-3	-2	-1	0
04	710	-3	-2	-1	0
05	600	-3	-2	-1	0
.....					
17	1	DAT			
18	1	DAT			
19	5	DAT			

Section 6.2 Operation of the LMC

Section 6.4 An Extended Instruction Set

8) Refer to the LMC program in question (7). How did the contents of mailboxes 17-19 change for each loop?

Sol: The contents of mailbox 17(value 1) is taken to the calculator and the value of mailbox 18 (value 1) is added to it in each loop. Thus in each loop, the value in 17 is incremented by 1. The value in 19 (value 5) stays the same in each loop.

Section 6.2 Operation of the LMC

Section 6.4 An Extended Instruction Set

9) What instruction should be placed in mailbox 02 so the program loops 4 times? Refer to the table of op codes above.

Mailbox	Contents
00	517
01	218
02	???
03	317
04	902
05	600
06	000
.....	
17	10
18	2

Sol: 02 701

Section 6.2 Operation of the LMC

Section 6.4 An Extended Instruction Set

10) Describe what the following LMC program does. Refer to the table of op codes above.

Mailbox	Contents
00	901
01	309
02	207
03	902
04	708
05	602
06	000
07	1
08	000
09	DAT

Sol:

Mailbox	Contents
00 901	Takes value from in basket and copies it to calculator.

01	309	Reads calculator value and loads onto mailbox (09).
02	207	Takes value from mailbox (07) and subtracts it from value in calculator.
03	902	Takes value from calculator and puts it in out basket
04	708	If value in calculator is 0, Go to mailbox (08). Else move on.
05	602	Go to mailbox (02)
06	000	Halt
07	1	DAT
08	000	Halt
09	DAT	

The program here takes a value from the in basket and decreases the value from mailbox 07 from it. As the value from mailbox 07 is 1, the value is decreased by 1 and the resulting value is given to the out basket. If the resulting value is equal to 0, the program stops. If it is not 0, the program loops back and the number is decreased by 1 again. The loop continues until the number is 0 and then halts.

Section 6.2 Operation of the LMC

Section 6.4 An Extended Instruction Set

11) The contents in memory occasionally have to be moved to another area of memory. When that happens, the mailbox references must be adjusted so that the program continues to function properly. Rewrite the LMC code in problem (10) so that it occupies mailboxes 05 through 14 only; mailboxes 01 through 04 will be used by another program, so they can't be used. Assume that instruction 605 remains in mailbox 00.

Mailbox	Contents
00	605
01	used by other program
02	used by other program
03	used by other program
04	used by other program
05	???
06	???
07	???
08	???
09	???
10	???
11	???
12	???
13	???
14	???

Sol:

Mailbox	Contents
00	605
01	used by other program
02	used by other program
03	used by other program
04	used by other program
05	901
06	314
07	212
08	902
09	713
10	607
11	000
12	1
13	000
14	DAT

12) Describe the LMC three-digit instruction format. How does the LMC know what part of the value is an instruction, and what part is an address?

Sol: All communication between the LMC and the outside world is done using three-digit numbers. We use the first digit of the three-digit number to tell the Little Man which operation to perform. This part is called opcode. We use the other two digits to indicate the appropriate mailbox address to be used as part of the instruction.

Section 6.2 Operation of the LMC

13) How does the LMC "know" if a particular mailbox contains data or instructions?

Sol: The LMC does not "know" if a particular mailbox contains data or instructions as both data and instructions are made of three-digit numbers. Thus if we store data in an address used by the Little Man for instructions, the Little Man would attempt to perform the data as though it were an instruction. This is a very important concept in computing, as it allows a programmer to treat an instruction as data, modify it and then execute the modified instruction.

Section 6.5 The Instruction Cycle

14) What happens if the LMC is executing a program and never encounters a "HALT" command?

Sol: If the LMC does not encounter a "HALT" command by the end of the program, the LMC will continue to areas that are not meant to be executed – empty addresses and addresses with data.

As the LMC cannot distinguish between instructions and data, the LMC would execute it as if they are instructions. Since there is no way to predict what the data might contain, there is no way to predict what the program might do.

Section 6.2 Operation of the LMC

15) Describe how the LMC is von Neumann architecture.

Sol: We need three things:

- 1) Memory hold both programs and data – stored program concept. This allows programs to be changed easily.
- 2) Memory is linearly addressed
- 3) Memory is accessed by the location number without regard to the data contained within