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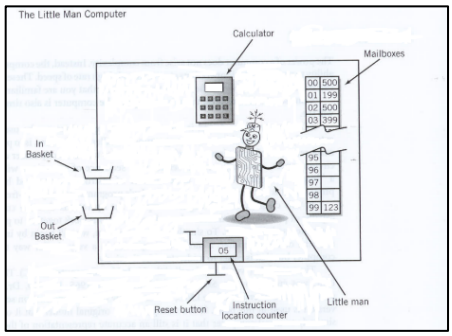
Chapter 6 The Little Man Computer

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 eachinstruction. The first one is completed as an example.

Mailbox	Contents	Result after completion
00	901	*Read contents from in basketand store in calculator*
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 (1st number) and store in calculator
01	319	Read value in calculator (1st number) and put it in the mailbox address 19. Calculator still contains the same number (1st number)
02	901	Read contents from in basket (2nd number) and replace the new number from the original number in Calculator
03	320	Read value in calculator (2nd number) and put it in the mailbox address 20. Calculator still contains the same number (2nd number)
04	219	Read value from mailbox address 19 (1st number) and subtract it from the value in calculator (2nd number – 1st number)
05	709	Check number in calculator. If it is equal to 0, the program jumps to execute instruction in mailbox address 09. If it is not, the program continues to execute instruction in mailbox address 06
06	518	Load the number in mailbox address 18 into calculator. The original number in calculator is replaced by the number from mailbox address 18
07	902	Read the current number in calculator and put it in the out basket
08	000	Stop the execution
09	517	Execute if the execution is jumped from instruction in mailbox address 05. Load the number in mailbox address 17 into calculator. The original number in calculator is replaced by the number from mailbox address 17
10	902	Read the current number in calculator and put it in the out basket
11	000	Stop the execution
---	---	
17	DAT	
18	DAT	
19	DAT	Store value from calculator. (Instruction 309 in mailbox address 00)
20	DAT	Store value from calculator. (Instruction 309 in mailbox address 02)

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.

a) What is the final value in outbasket if the first in basket is 56 and second in basket is 89?
b) What is the final value in outbasket if the first in basket is 75 and second in basket is 75?
c) 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.

a) 1
b) 5
c) 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: Initially, the program reads the first input number from in basket and stores it in the calculator then the program reads the number in the calculator and stores it in the mailbox 19. After that, the program reads the second number from in basket and stores in the calculator then the program reads the number in the calculator and stores it in the mailbox 20. Currently, the calculator contains the second number. From the instruction of mailbox 04, the program subtract the number in the calculator by the number in mailbox 19 which is the first number that is stored since the instruction of mailbox 01. After the program checks the current number in the calculator that it is equal to zero of not. If it is not, the program continues to execute the instruction in the next mailbox (mailbox 06) which is to load the number in the mailbox 18 (1) to the calculator. After that, the program reads this number from the calculator and put it in out basket as the output by the instruction of mailbox 07 before the programs is ended by the instruction of mailbox 08. In case of the number is checked to be equal to zero by the instruction of mailbox 05, the program jumps to execute the instruction of mailbox 09 which is to load the number in the mailbox 17 (5) to the calculator. After that, the program reads this number from the calculator and put it in out basket as the output by the instruction of mailbox 10 before the programs is ended by the instruction of mailbox 11.

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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	
01	218	
02	902	
03	705	
04	601	
05	000	
.....		
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
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6) Describe what the LMC program in question (4) does.

Sol: Firstly, The program loads the number in mailbox 17 (100) into the calculator then subtract it by the number in mailbox 18 (2) which makes the number in the calculator is 98 before this number is put into out basket as the first output number. After that, the current number in the calculator (98) is checked by the instruction of mailbox 03 that it is equal to zero or not. If it is not, the program continues to execute the instruction of mailbox 04 which instructs the program to jump back to execute the instruction of mailbox 01 and continue step by step until the instruction of mailbox 04 again as a loop. This loop will continue until the number is equal to zero then the program jumps to execute the instruction of mailbox 05 to end the program.

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	Depends on instruction in mailbox address 10
05	600		-3	-2	-1	This instruction is jumped over (Not execute)
…….						
17	1	DAT	2	3	4	5
18	1	DAT	1	1	1	1
19	5	DAT	5	5	5	5

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:

Mailbox 17 is changed :

The number is added by the instruction in mailbox 01 in each loop, then after addition, the original number in mailbox 17 is replaced by the instructionof mailbox 00 at the beginning of each loop.

Mailbox 18 and 19 not changed :

The number in mailbox 18 is used by the instruction of mailbox 01 but there is no instruction in any mailboxes to change or replace the original number in mailbox 18.

Section 6.2 Operation of the LMC
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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		Loop1	Loop2	Loop3	Loop4
00	517	10	8	6	4	2
01	218	8	6	4	2	0
02	??? -> 706					Jump to execute mailbox 06
03	317	8	6	4	2	
04	902	8	6	4	2	
05	600					
06	000					
…….						
17	10	8	6	4	2	
18	2					

Sol: 706

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: The programs starts by reading the number from in basket and stores it in the calculator then the problem reads this number from the calculator and stores it in mailbox 09. After that, the program executes the instruction of mailbox 02 to subtract the current number in the calculator by the number in mailbox 07 before the program reads the final number in the calculator and put it in outbasket as the output number by the instruction of mailbox 03. The program then checks the current number in the calculator that it is equal to zero or not. If it is not, the program continues to execute the instruction of mailbox 05 which instructs the program to jump back to execute the instruction of mailbox 02 and continue step by step until the instruction of mailbox 05 again as a loop. This loop will continue until the number in the calculator is equal to 0 then the program will stop working by the instruction of mailbox 08.

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 tofunction 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	309
07	207
08	902
09	708
10	602
11	000
12	1
13	000
14	DAT

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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: For the three-digit instruction format, the first digit (leftmost digit) represents the instruction because the instruction only requires one digit, and the other two digits indicate the appropriate mailbox address to be used as a 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 steps that the Little Man takes to perform an instruction are divided into 2 instruction cycles, including of the fetch cycle and the execute cycle. Firstly, the program performs the fetch cycle to find out what instruction to execute. After that the execute cycle occurs, the program performs the work specified in the instruction that the program found in the fetch cycle.

Therefore, LMC knows that a particular mailbox contains instructions and data from the fetch cycle and the execute cycle, respectively.

Section 6.5 The Instruction Cycle

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

Sol: The program will not stop working and keep executing until it finds the mailbox that contains the instruction to stop (HALT command or “000”).

Section 6.2 Operation of the LMC

15) Describe how the LMC is von Neumann architecture.

Sol: We need three things:

1) Memory holds both instructions and data.

2) Memory is addressed linearly. Every memory location contains a single sequential numeric address.

3) Memory is addressed by the location number without regard to the data contained within.