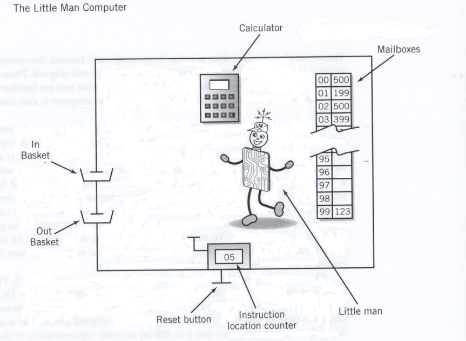
Chapter 6 The Little Man Computer

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 and store in calculator

01 319 Store value of calculator in mailbox 19

02 901 Read contents from in basket and store in calculator

03 320 Store value of calculator in mailbox 20

04 219 Subtract the value in calculator by value in mailbox 19

05 709 Branch to mailbox 09 if calculator is 0

06 518 Load value in mailbox 18 to calculator

07 902 Move value in calculator to out basket

08 000 Halt

09 517 Load value in mailbox 17 to calculator

10 902 Move value in calculator to out basket

11 000 Halt

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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.

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) 5 (56 and 89 are different)

b) 1 (75 and 75 are the same)

c) 5 (56 and 89 are different)

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 order of input does not matter. This program displays to the out basket "5" if the inputs are different, and a “1” if they are same.

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

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

Section 6.4 An Extended Instruction Set

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

Sol: The program displays baskets from an even number to a countdown from 98. The first number displayed is 98, and the last number displayed is 0.

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 content of address 17 will be: 2-3-4-5. The others won’t change.

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: The contents of address 02 should be 706 after the program loopa 4 times.

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 program gets a number from the user. Then it loops by that number displaying the loop count to the out basket each time. Example: in basket 4: display to out basket: 3 - 2 - 1- 0.

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

06 314

07 212

08 902

09 713

10 606

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: The format of an instruction takes the form XYY where X is the op code (0-9) and YY is the address (00-99). No op code X=4. The LMC only has to check the first digit for the opcode; the remaining 2 digits are an address.

Section 6.2 Operation of the LMC

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

Sol: LMC does not know if the value in a mailbox is an instruction or not. The first instruction location is 00 and the next is determined by the program counter. If the LMC happens upon a memory value that wasn’t intended to be an instruction, the LMC would try to execute it. Alternatively, if the program counter points to a particular mailbox, it is assumed to contain an instruction, not data.

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 continue to execute until it encounters a location that contains “000” (the HALT instruction, even it it’s data) or a location that begins with a 4, which is an invalid operation code. This assumes that incrementing the program counter past 99 returns it to zero.

Section 6.2 Operation of the LMC

15) Describe how the LMC is von Neumann architecture.

Sol: We need three things:

1) The computer consists of a CPU and memory, with facility for input and output.

2) The memory holds both instructions and data.

3) The instructions are executed sequentially, that is, one at a time.