UNIVERSITY OF PUNE

LAB COURSE I
SYSTEM PROGRAMMING
AND
OPERATING SYSTEM
(CS-331)

T.Y.B.SC.(COMPUTER SCIENCE)
SEMESTER I

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About the Work Book

Objectives of this book

This workbook is intended to be used by T.Y.B.Sc(Computer Science) students for the Three computer science laboratory courses.

The objectives of this book are

1. The scope of the course.
2. Bringing uniformity in the way course is conducted across different colleges.
3. Continuous assessment of the students.
4. Providing ready references for students while working in the lab.

How to use this book?

This book is mandatory for the completion of the laboratory course. It is a measure of the performance of the student in the laboratory for the entire duration of the course.

Instructions to the students

1) Students should carry this book during practical sessions of computer science.
2) Students should maintain separate journal for the source code and outputs.
3) Student should read the topics mentioned in **Reading section** of this book before coming for practical.
4) Students should solve only those exercises which are selected by practical in-charge as a part of journal activity. However, students are free to solve additional exercises to do more practice for their practical examination.

Exercise Set	Difficulty Level	Rule
Self Activity	NA	Student should solve these exercises for practice only.
SET A	Easy	All exercises are compulsory.
SET B	Medium	At least one exercise is mandatory.
SET C	Difficult	Not Compulsory.

5) Students will be assessed for each exercise on a scale of 5

1.Not Done 0
2. Incomplete 1
3.Late Complete 2
4.Needs Improvement 3
5.Complete 4
6.WellDone 5

Instructions to the Practical In-charge

1) Explain the assignment and related concepts in around ten minutes using white board if required or by demonstrating the software.
2) Choose appropriate problems to be solved by student.
3) After a student completes a specific set, the instructor has to verify the outputs and sign in the provided space after the activity.

4) ENSURE THAT THE STUDENTS USE GOOD PROGRAMMING PRACTICES.
5) YOU SHOULD EVALUATE EACH ASSIGNMENT CARRIED OUT BY A STUDENT ON A SCALE OF 5 AS SPECIFIED ABOVE TICKING APPROPRIATE BOX.
6) THE VALUE SHOULD ALSO BE ENTERED ON ASSIGNMENT COMPLETION PAGE OF RESPECTED LAB COURSE.

Assignment Number: 1
Title: Line Editor

Ready Reference:

A **line editor** is a text editor computer program that manipulates text primarily by the display, modification, and movement of lines.

Line editors are limited to primitive text-oriented input and output methods. Most edits are a line-at-a-time. Typing, editing, and document display do not occur simultaneously. Typically, typing does not enter text directly into the document. Instead, users modify the document text by entering terse commands on a text-only terminal. Commands and text, and corresponding output from the editor, will scroll up from the bottom of the screen in the order that they are entered or printed to the screen. Although the commands typically indicate the line(s) they modify, displaying the edited text within the context of larger portions of the document requires a separate command.

Command	**Meaning**
a	To append
p	To display
p m n	To display range of lines
p m – n	To display previous n lines from m^th^ position
s	Save
d n	To delete nth line
d m n	To delete range of lines
f <pat>	To search pattern
i n	To insert after n^th^ line
m n1 n2	To move line n1 at n2 position
m n1 n2 n3	To move range of lines at n3
c n1 n2	To copy line n1 at position n2
c n1 n2 n3	To copy range of lines at n3
h	To give help information about all commands

Algorithm :

The name of the file to be edited is to be taken as a command line argument. Open a empty file if no argument is supplied.

Declare a node structure containing a character array to hold a line and two pointers. One pointing to previous node and one to next node (Implement the line editor using doubly linklist.)

Write separate functions for each of the above operations.

Your program should display a prompt to accept the command.

Operation :

1. a : (To append)	Accept the line from the user. Using the pointers move to the end of the list

	Create a new node and write the line in it Append the new node at the end of the present linked list
2. p : (To print or display)	Go to the starting of the linked list Print the contents of each node Traverse to the end of the linked list
3. p m n (To display a range of lines)	Accept m and n from the user Traverse from the starting of the linked list to the mth node Starting from the mth node, print the contents of the next n nodes.
4. p m - n (To display previous n lines)	Accept m and n from the user Traverse from the starting of the linked list to the mth node using the previous pointer of each node, traverse backward, and print the contents of the previous n nodes
5. s (Save)	Accept file name from user Create a new file with that name Traverse the link list and write the contents of each node to the file
6. d n	Accept n from the user Traverse the linked list from beginning to n-1th position. Change the next pointer of n-1 th node to point to n +1 th node, and the previous pointer of n + 1 th node to point to n – 1 th node Delete the nth node
7. d m n	Accept m and n from the user Traverse the linked list from beginning to m-1th position. Take another pointer and make it traverse n nodes from the mth node. Change the next pointer of m-1 th node to point to the next node after n nodes, and the previous pointer of this next node to point to the m – 1 th node Delete all the node in between

8. f <pat> : Accept the pattern from the user
Traverse the linked list from beginning to end and for each node where the pattern is found, print the node no.

9. i n : Accept the new line and n from the user
Traverse the linked list from first position to nth position
Create a new node to hold the new line
Insert this node after the nth node

10. m n1 n2 : Accept n1 and n2 from the user
Take two pointers and traverse the linked list so that one pointer is at n1th node and second pointer is at n2th node.
Change the previous and next pointers so that the n1th node is moved after the n2th node.

11. m n1 n2 n3 : Accept n1, n2 and n3 from the user
Take three pointers and traverse the linked list so that one pointer is at n1th node, second pointer is at n2th node, and the third pointer is at the n3rd node
Change the previous and next pointers so that the nodes from n1 to n2 are moved after the n3rd node.

12. c n1 n2 : Accept n1 and n2 from the user
Take two pointers and traverse the linked list so that one pointer is at n1th node and second pointer is at n2th node.
Create a new node and copy the contents of the n1 th node to the new node
Append this new node after the n2th node.

13. c n1 n2 n3 : Accept n1, n2 and n3 from the user
Take three pointers and traverse the linked list so that one pointer is at n1th node, second pointer is at n2th node, and the third pointer is at the n3rd node
Make as many new nodes as required ad copy the lines from n1 to n2 into these new nodes
Insert these new nodes after the n3rd node.

14. h : Display help for all the commands.

Set A

1) Write a command line program for line editor. The file to be editied is taken as command line argument; an empty file is opened for editing if no argument is supplied. It should display a '$' prompt to accept the line editing commands. Implement the following commands:
   i. a
   ii. d n
   iii. d m n
   iv. s

2) Write a command line program for line editor. The file to be edited is taken as command line argument; an empty file is opened for editing if no argument is supplied. It should display a '$' prompt to accept the line editing commands. Implement the following commands:
   i. a
   ii. p
   iii. p m n
   iv. i n

Set B

1) Write a command line program for line editor. The file to be edited is taken as command line argument; an empty file is opened for editing if no argument is supplied. It should display a '$' prompt to accept the line editing commands. Implement the following commands:
   i. a
   ii. p
   iii. m n1 n2
   iv. m n1 n2 n3

3) Write a command line program for line editor. The file to be edited is taken as command line argument; an empty file is opened for editing if no argument is supplied. It should display a '$' prompt to accept the line editing commands. Implement the following commands:
   i. a
   ii. s
   iii. c n1 n2
   iv. c n1 n2 n3

Set C

1) Write a command line program for line editor. The file to be edited is taken as command line argument; an empty file is opened for editing if no argument is supplied. It should display a '$' prompt to accept the line editing commands. Implement the following commands:

i. a
ii. p m – n
iii. f <pat>
iv. h

Assignment Evaluation

0:Not Done [ ] 1:Incomplete [ ] 2.Late Complete [ ]
3:Needs Improvement [ ] 4:Complete [ ] 5:WellDone [ ]

Signature of the Instructor Date of Completion

Assignment Number : 2

Title : Simulator

Ready reference :

Hypothetical Machine:

- Not Real Machine but used to illustrate features of machine language and techniques used in assembler.
- The Addresses From 0,1,2,3,… and these addresses are accessible to programmers.
- The machine has six condition codes from 0 to 5
- This machine can not handle string data.

Simulator:

- Simulator is the program which can execute machine program of hypothetical machine and produce result.
- The software which gives fill of the things which not really exist is called as simulator.

Need Of simulator:

- Using simulator less time is required for debugging of simple programs.
- It is easier for programmer to explain complex problems if you have a simulator.
- It is easier to discover if a problem is in the hardware or software when you use a simulator.
- The simulator requires **no** setup time.
- One of the primary advantages of simulators is that they are able to provide users with practical feedback when designing real world systems.

Instruction Set :

Opcode	Mnemonic	Format
01	ADD	[Label] ADD op1 op2

02	SUB	[Label] SUB op1 op2
03	MULT	[Label] MULT op1 op2
04	MOVER	[Label] MOVER op1 op2
05	MOVEM	[Label] MOVEM op1 op2
06	COND	[Label] COMP op1 op2
07	BC	[Label] BC op1 op2
08	DIV	[Label] DIV op1 op2
09	READ	[Label] READ op2
10	PRINT	[Label] PRINT op2
11	STOP	[Label] STOP

Conditional codes:

Opcode	Condition
0	LT (Less Than)
1	LE (Less than or equal to)
2	EQ (Equal to)
3	GT (Greater than)
4	GE (Greater than or equal to)
5	ANY

****

Examples:

1. Program for addition of two numbers taken fromuser input

```
              READ     A
              READ     B
              MOVER    AREG    A
              ADD      AREG    B
              MOVEM    AREG    RES
              PRINT    RES
              STOP
      A       DS       1
      B       DS       1
    RES       DS       1
              END
```

Hear Address are not given so, give the address 0 to first instruction, 1 to next and so on as follows.

```
0.        READ      A
1.        READ      B
2.        MOVER     AREG    A
3.        ADD       AREG    B
4.        MOVEM     AREG    RES
5.        PRINT     RES
```

```
6.              STOP
7.  A           DS        1
8.  B           DS        1
9.  RES         DS        1
10.             END
```

Then write the opcode program using given codes and addresses as follows.

```
090007          //09 for read   0   as no register is used        007    address of   A

090008          //09 for read   0   as no register is used        008    address of   B

041007          //04 for moving content of memory location 007  to  register
                       AREG    1  for    register  AREG     007    address of   A

011008          //01 for addition of   content at  008   to register AREG

051010          //05 for moving content of AREG to memory location 010
                       1    as no register is used   010    address of   RES
100010         //10   print    the content at memory location       010 on screen.

110000         //11  to stop program execution.

     0         //for data input

0              //for data input

0
```

This Opcode file is the input for simulator.

****

Data Structures Used:

Mem[ ] : To Store Opcode instruction.
Cond[] : To Store Conditions.
REG[] :To Store Register Contents.
PC : Program Counter

****

Algorithm:

Step 1: Start.
Step 2: Open Object Code File.

```
Step 3:  Read All File and Store All Instructions in Mem[] Array.
Step 4: Close Object File.
Step 5: PC=0.
Step 6: Separate Instruction, operand 1,operand 2 from each instruction whose address
        is PC.
Step 7: If Instruction is
        1:  REG[operand1-1] + = Mem[operand2]
            GOTO step 8
        2:  REG[operand1-1] - = Mem[operand2]
            GOTO step 8
        3:  REG[operand 1-1] * = Mem[operand2]
            GOTO step 8
        4:  REG[operand1-1]   =   Mem[operand2]
            GOTO step 8
        5:  Mem[operand2]  =  REG[operand1-1]
            GOTO step 8
        6: If  REG[operand1-1] < Mem[operand2]
            then Cond[0] = 1  else  Cond[0]=0

            If  REG[operand1-1] < = Mem[operand2]
            then Cond[1] = 1  else  Cond[1]=0

            If  REG[operand1-1] = = Mem[operand2]
            then Cond[2] = 1  else  Cond[2]=0

            If  REG[operand1-1] > Mem[operand2]
            then Cond[3] = 1  else  Cond[3]=0

            If  REG[operand1-1] > = Mem[operand2]
            then Cond[4] = 1  else  Cond[4]=0
            GOTO step 8.

        7: If Cond[operand1-1] = = 1 then PC=operand2 then goto Step 6.
           Else GOTO Step 8.

        8: REG[operand1-1]/=Mem[operand2]
            GOTO Step 8.
        9: Accept  Mem[operand2]
            GOTO Step 8.
        10:Print  Mem[operand2]
            GOTO Step 8.

        11:GOTO Step 9.

Step 8:    PC++
        GOTO step 6.
```

Step 9: Stop execution.

****

SET A:

1. Write a SMAC0 CPU simulator program in C for the following instruction set

Mnemonic	Opcode	Meaning
MOVER	01	Move memory operand contents to register
MOVEM	02	Move register operand contents to memory
READ	03	Read into memory operand
PRINT	04	Print contents of memory operand
COMP	05	Compare register & mem operand to set condition code appropriately
BC	06	Branch to 2nd operator depending on cond code specified as 1st operand
MULT	07	Multiply memory operand to register operand
DIV	08	Divide memory operand to register operand
ADD	09	Add memory operand to register operand
SUB	10	Subtract memory operand to register operand
STOP	11	Stop of halt execution

Assemble following program manually and execute it using above simulator.

```
         READ   N
         MOVER  AREG,  N
         COMP   AREG,  ZERO
         BC     LT,    SHOW1
         COMP   AREG,  ZERO
         BC     GE,    SHOW
SHOW     PRINT  ONE
         STOP
SHOW1    PRINT  ZERO
         STOP
N        DS     1
ONE      DC     1
ZERO     DC     0
         END
```

2. Write a SMAC0 CPU simulator program in C for the following instruction set

Mnemonic	Opcode	Meaning
READ	01	Read into memory operand
PRINT	02	Print contents of memory operand

STOP	03	Stop of halt execution
ADD	04	Add memory operand to register operand
SUB	05	Subtract memory operand to register operand
MOVER	06	Move memory operand contents to register
MOVEM	07	Move register operand contents to memory
MULT	08	Multiply memory operand to register operand
DIV	09	Divide memory operand to register operand
BC	10	Branch to 2nd operator depending on cond code specified as 1st operand
COMP	11	Compare register & mem operand to set condition code appropriately

Assemble following program manually and execute it using above simulator.

```
                READ N
 LOOP           MOVER       AREG,SUM
                ADD         AREG,N
                MOVEM       AREG,SUM
                MOVER       AREG,N
                SUB         AREG,ONE
                COMP       AREG, ZERO
                BC          LE,     OUT
                MOVEM       AREG,N
                BC          ANY,  LOOP
OUT             PRINT SUM
                STOP
N               DS      1
ZERO  DC        0
ONE             DC      1
SUM             DC      0
                END
```

3: Write a SMAC0 CPU simulator program in C for the following instruction set

Mnemonic	Opcode	Meaning
STOP	01	Stop of halt execution
SUB	02	Subtract memory operand to register operand
ADD	03	Add memory operand to register operand
DIV	04	Divide memory operand to register operand
MULT	05	Multiply memory operand to register operand
PRINT	06	Print contents of memory operand
READ	07	Read into memory operand
MOVEM	08	Move register operand contents to memory
MOVER	09	Move memory operand contents to register
BC	10	Branch to 2nd operator depending on cond code specified as 1st operand
COMP	11	Compare register & mem operand to set condition code appropriately

Assemble following program manualy and execute it using above simulator.

```
            READ N
LOOP  MOVER       AREG,N
            MULT AREG,        I
            MOVEM       AREG,ANS
            PRINT       RES
            MOVEM       AREG,I
            ADD         AREG,ONE
            COMP        AREG,TEN
            BC          GE,     HALT
            MOVEM       AREG,  I
            BC          ANY,  LOOP
HALT        STOP
N           DS          1
RES         DS          1
I           DC          1
ONE         DC          1
TEN         DC          10
            END
```

****
SET B:

1: Write a SMAC0 CPU simulator program in C for the following instruction set

Mnemonic	Opcode	Meaning
MOVER	01	Move memory operand contents to register
MOVEM	02	Move register operand contents to memory
READ	03	Read into memory operand
PRINT	04	Print contents of memory operand
COMP	05	Compare register & mem operand to set condition code appropriately
BC	06	Branch to 2nd operator depending on cond code specified as 1st operand
MULT	07	Multiply memory operand to register operand
DIV	08	Divide memory operand to register operand
ADD	09	Add memory operand to register operand
SUB	10	Subtract memory operand to register operand
STOP	11	Stop of halt execution

Assemble following program manualy and execute it using above simulator.

```
READ     X
READ     Y
MOVER    AREG,  ONE
MOVEM    AREG,  ANS
```

```
          MOVEM   AREG,  COUNT
   AGAIN  MOVER   BREG,  COUNT
          MULT    BREG,  X
          MOVEM   BREG,  ANS
          MOVER   AREG,  COUNT
          ADD     AREG,  ONE
          MOVEM   AREG,  COUNT
          COMP    AREG,  Y
          BC    LE,   AGAIN
          PRINT  ANS
          STOP
  COUNT DS     1
    ONE  DC     1
       X  DS     1
       Y  DS     1
    ANS  DS     1
          END
```

2: Write a SMAC0 CPU simulator program in C for the following instruction set

Mnemonic	Opcode	Meaning
MOVER	01	Move memory operand contents to register
MOVEM	02	Move register operand contents to memory
READ	03	Read into memory operand
PRINT	04	Print contents of memory operand
COMP	05	Compare register & mem operand to set condition code appropriately
BC	06	Branch to 2nd operator depending on cond code specified as 1st operand
MULT	07	Multiply memory operand to register operand
DIV	08	Divide memory operand to register operand
ADD	09	Add memory operand to register operand
SUB	10	Subtract memory operand to register operand
STOP	11	Stop of halt execution

Assemble following program manually and execute it using above simulator.

```
          READ        N
          MOVER       AREG,ONE
          MOVEM  AREG,   FACT
          MOVEM  AREG,   COUNT
   LOOP  MOVER       BREG,COUNT
          MULT        BREG,FACT
          MOVEM       BREG,FACT
```

```
            MOVER       AREG,COUNT
            ADD  AREG,ONE
            MOVEM       AREG,COUNT
            COMP        AREG,N
            BC     LE,  LOOP
            PRINT       FACT
            STOP
    COUNT  DS      1
    ONE    DC      1
      N     DS      1
      FACT  DS      1
           END
      ***************************************************************
```

SET C:

1:Write a SMAC0 CPU simulator program in C for the following instruction set

Mnemonic	Opcode	Meaning
MOVER	01	Move memory operand contents to register
MOVEM	02	Move register operand contents to memory
READ	03	Read into memory operand
PRINT	04	Print contents of memory operand
COMP	05	Compare register & mem operand to set condition code appropriately
BC	06	Branch to 2nd operator depending on cond code specified as 1st operand
MULT	07	Multiply memory operand to register operand
DIV	08	Divide memory operand to register operand
ADD	09	Add memory operand to register operand
SUB	10	Subtract memory operand to register operand
STOP	11	Stop of halt execution

Assemble following program manually and execute it using above simulator.

```
          READ    N
          MOVER   AREG,  ZERO
          MOVEM   AREG,  SUM
          MOVEM   AREG,  COUNT
   AGAIN  MOVER   BREG,  SUM
          ADD    BREG,  COUNT
```

```
             MOVEM   BREG,  SUM
             MOVER   AREG,  COUNT
             ADD     AREG,  ONE
            MOVEM   AREG,  COUNT
            COMP    AREG,  N
            BC      LE,    AGAIN
            PRINT   SUM
            STOP
   COUNT DS     1
     ONE   DC     1
       N     DS     1
    ZERO  DC     1
    SUM   DS     0
          END
```

Assignment Evaluation

0:Not Done [ ]   1:Incomplete [ ]   2.Late Complete [ ]
3:Needs Improvement [ ]   4:Complete [ ]   5:WellDone [ ]

Signature of the Instructor   Date of Completion

Assignment No.: 3

Title: **Assembler**

Ready Reference:

Objective of this assignment is to write a C program that will accept a input file which contains assembly language program using given instruction and translate the contents of input file in to target file which is machine code specified in instruction code. Program will execute in two parts. In first part it will accept input file and translate it into intermediate code. In second part it will take intermediate code as input and convert it into target code for error free input program .Program will also list out the errors from input file for different types of errors.

Definition

Programming language processor that translates an assembly language program (the source program) to the machine language program (the object program) executable by a computer.

One pass assembler

A one pass assembler passes over the source file exactly once, in the same pass collecting the labels, resolving future references and doing the actual assembly. The difficult part is to resolve future label references and assemble code in one pass.

Two pass assembler

A two pass assembler does two passes over the source file (the second pass can be over a file generated in the first pass). In the first pass all it does is looks for label definitions and introduces them in the symbol table. In the second pass, after the symbol table is complete, it does the actual assembly by translating the operations and so on.

Operation Code	Mnemonic
00	STOP
01	ADD
02	SUB
03	MULT
04	MOVER
05	MOVEM

Data Structure of Assembler:

Data structure used in assembler is basically of two types

a) Data Structure contains information of machine: Not updated during translation called predefined data structure.
   They are
   a) Operation code table (OPTAB) :This is used for storing mnemonic, operation code and class of instruction
      Structure of OPTAB is as follows

06	COMP
07	BC
08	DIV
09	READ
10	PRINT

b) REGISTER TABLE (REGTAB): used to store register name & there code.

Register name	Code
AREG	1
BREG	2
CREG	3
DREG	4

c) CONDITION CODE TABLE (CCTAB) : Used to store condition code

Condition Code	Code
LT	1
LE	2
EQ	3
GT	4
GE	5
ANY	6

b) Data structure updated during translation: Also called as translation time data structure. They are

I. SYMBOL TABLE (SYMTAB) : Ii contains entries such as symbol,it's address and value.

SYMBOL	ADDRESS	VALUE

II. LITERAL TABLE (LITTAB) : it contains entries such as literal and it's value.

LITERAL	VALUE

III . POOL TABLE (POOLTAB): Contains literal number of the starting literal of each literal pool.

IV: Location Counter which contains address of next instruction by calculating length of each instruction.

ALGORITHM

PASS 1

- Initialize location counter, entries of all tables as zero.
- Read statements from input file one by one.
- While next statement is not END statement
    - I. Tokenize or separate out input statement as label,numonic,operand1,operand2
    - II. If label is present insert label into symbol table.
    - III. If the statement is LTORG statement processes it by making it's entry into literal table, pool table and allocate memory.
    - IV. If statement is START or ORIGEN
        Process location counter accordingly.
    - V. If an EQU statement, assign value to symbol by correcting entry in symbol table.
    - VI. For declarative statement update code, size and location counter.
    - VII. Generate intermediate code.
    - VIII. Pass this intermediate code to pass -2.

PASS -2

1. Initialize memory, table entries, and location counter.
2. While next statement is not END
    - a) If statement is LTORG statement then process literal ie assemble literal into machine code.
    - b) For START/ORIGIN statement process location counter.
    - c) For declarative statements assemble constants into machine code.
    - d) For imperative statements get operand address from symbol table or literal table and assemble it to machine code.
    - e) If the instruction is in OPTAB get appropriate opcode into intermediate code.
    - f) Move the contents to target code.
    - g) Print output file.

SET A

Q1. Write a program to accept a program written in assembly language. After accepting entire program list out errors wherever applicable.

a) Symbols used but not defined
b) Symbols declared but not used

c) Redeclaration of symbols

Consider following program as input

```
        START       100
        READ        X
Y       MOVER       BREG, X
        ADD         BREG, X
X       MOVEM       AREG, Z
        STOP
        X      DS   1
        Y      DS   1
        END
```

Q2. Write a program to accept a program written in assembly language. After accepting entire program list out errors wherever applicable.

a) Invalid statement
b) Invalid mnemonic

Consider following program as input

```
        START       100 ,2
        READ        A
        MOVER       A,AREG
        BDD         AREG, A
A       MOVEM       AREG, ‘=2’
        STOP
        X      DS   1
        Y      DS   1
        END
```

Q3. Write a program to accept a program written in assembly language. After accepting entire program list out errors wherever applicable.

a) Symbols used but not defined
b) Symbols declared but not used
c) Redeclaration of symbols
d)Invalid symbol name

Consider following program as input

```
        START       100
        READ        A
        MOVER       AREG, ORIGIN
        ADD         AREG, A
A       MOVEM       AREG, C
        STOP
```

```
        X       DS      1
        Y       DS      1
        END
```

Q4. Write a c program that will read given assembly language program as input. Display the contents of SYMBOL TABLE, LITERAL TABLE and POOL TABLE.

Consider following program as input.

```
                START 100
                MOVER AREG, =5
                MOVER BREG, =1
                MOVER BREG, A
                LTORG
                MOVER CREG, =4
                MOVER DREG, =1
                MOVER BREG, B
                PRINT A
                STOP
        A        DS      1
        B        DC     2
                END
```

SET B:

Q1 Write a assembler for error free assembly language program that will generate target code. Display the contents of symbol table. Also display target code generated.

Consider following program

```
                READ            N
LOOP            MOVER           AREG,           SUM
                ADD             AREG            N
                MOVEM           AREG            SUM
                MOVER           AREG            N
                SUB             AREG,           ONE
                COMP            AREG            ZERO
                BC              LE              OUT
                MOVEM           AREG            N
                BC              ANY             LOOP
OUT             PRINT           SUM
                STOP
N               DS      1
ZERO            DC      ‘0’
ONE             DC      ‘1’
SUM             DC      ‘0’
                END
```

Q 2 : Write a assembler for error free assembly language program that will generate target code. Display the contents of symbol table, literal table. pool table. Also display target code generated.

Consider the following program as input

```
                START       200
                MOVER       AREG,    ='5'
                MOVEM       AREG,     A
LOOP            MOVER      AREG,      A
                MOVER      CREG,       B
                ADD         CREG,    ='1'
                BC          ANY,    NEXT
                LTORG
                        ='5'
                        ='1'
NEXT            SUB         AREG,   ='1'
                BC         LT        BACK
LAST            STOP
                ORIGIN      LOOP+2
                MULT        CREG,          B
                ORIGIN      LAST+1
A                DS          1
BACK            EQU         LOOP
B               DS           1
                END
```

Assignment Evaluation

0:Not Done [ ]   1:Incomplete [ ]   2.Late Complete [ ]

3:Needs Improvement [ ]   4:Complete [ ]   5:WellDone [ ]

Signature of the Instructor   Date of Completion

Assignment Number:- 4
Title: Macro Preprocessor
Ready Reference:
Topic:

Macro is a facility for extending the set of operations provided in an assembly language through incorporation of new operations desired by a programmer.

A macro definition is enclosed between MACRO and MEND keywords.

Eg.

```
MACRO                      ← Macro header statement.
INCR &X, &Y, &REG=AREG           ← Macro prototype statement
MOVER &REG,  &X          }      Model statements
ADD    &REG, &Y          }
MOVEM &REG, &X           }
MEND                       ← End of definition unit
```

Parameters used in the prototype statement are formal parameters, starting with special character &. When certain formal parameters have default values, it can be specified using '=' sign and are called as keyword parameters. Formal parameters without default values are called as positional parameters.

Macro Preprocessor is a program that take an assembly language program (source program) with macro definition and macro calls as input and generates an assembly program without any macro definitions and calls (i.e. it should perform macro expansion) as an output.

Eg.

```
i)  INCR P,Q                        }  A macro calls
ii) INCR P,Q, &REG= BREG            }
```

The Macro Preprocessor will expand the macro call as follows:

```
i)    MOVER AREG, P
      ADD    AREG,  Q
      MOVEM AREG, P
```

```
ii)   MOVER BREG, P
      ADD    BREG,  Q
      MOVEM BREG, P
```

Data structures used by Macro Preporcessor:

1. Macro Name Table (MNT) : Maintains following details

Macro Name	Number of Positional Prarameters(#PP)	Number of Keyword Prarameters(#KP)	Macro Definition Table Pointer (MDTP)	Keyword Parameter Table Pointer (KPDTP)

2. Parameter Name Table (PNTAB): Maintains the list of formal parameters.

3. Keyword Parameter Table (KPDTAB): Maintains the list of keyword parameters and corresponding default values.

4.Macro Definition Table (MDT) : Stores the macro definition (prototype statements), which is required for macro expansion.

5. Actual Parameter Table (APTAB) : Maintains the list of actual parameters, which has to be used during macro expansion.

Design of a Macro Preprocessor :

Step 1: Scan all macro definitions one by one for each macro defined.
- i) Enter their names in the Macro Name Table (MNT).
- ii) count number of positional and keyword parameters and add it in MNT (#KP,#PP).
- ii) Store list of keyword parameters with their default values in Keyword Parameter Default Table (KPDTAB)
- iii) Store the entire macro definition in the Macro Definition Table (MDT).
- iv) Add additional information to MNT indication where the keyword parameters and macro definition of a macro can be found (KPDTP, MDTP)

Step 2: Examine all the statements in source program to detect macro calls. For each macro call
- i) locate the macro in MNT.
- ii) Obtain information from MNT regarding position of the macro definition in MDT.
- iii) Process the macro call statements to establish correspondence between all formal parameters and their values (actual parameters)

Step 3 : Expand the macro call by processing the statements in the MDT in a sequence until the MEND statement is encountered.

Set A:
Write program for macro preprocessor which will

1. Specify proper declarations of MNT(macro name, ppcount, kpcount, kptp, mdtp), MDT(macro definition), PNTAB(name),KPTAB(name, value).
2. Create a file trial.asm as follows

   ```
   MACRO
   CALC &X,&Y,&REG=BREG,&OP=ADD
   MOVER &REG,&X
   &OP &REG, &Y
   MOVEM &REG, &X
   MEND
   READ A
   READ B
   CALC A,B, &OP=MULT
   STOP
   A DS 1
   B DS 1
   END
   ```
3. Program should read the input file given as command line argument and display it.

Set B:

1. Write code to identify a macro definition, separate macro prototype statement and make entry in proper tables.

```
// separate ( ) to separate macro prototype statement
//addmnt( ) to make proper entries in MNT
//addpntab( ) to make entries in PNTAB
// addkptab to make entries in KPTAB.
```

2.Write appropriate functions to display contents of MNT, KPTAB, PNTAB tables.

```
//displaymnt( ) to display contents of MNT
// displaykpt( ) to display contents of KPTAB
//displaypnt() to display contents of PNTAB
```

Set C:

1. Write appropriate function which returns the position if the macro name is present in MNT otherwise returns -1. Write similar function to search for specific keyword parameter. Write code for processing the macro definition and to display contents of MDT.

```
// addmdt( ) make entries in MDT
//displaymdt ( ) displays contents of MDT as
 MOVER (p,3) (p,1)
(p,4) (p,3) (p,2)
```

```
    :
    :
MEND
```

2. Write function expand( ) to expand the macro call by building appropriate APL. Display the assembly language program with expanded macro calls and show the contents of all data structures.

Assignment Evaluation

0:Not Done [ ]	1:Incomplete [ ]	2.Late Complete [ ]
3:Needs Improvement [ ]	4:Complete [ ]	5:WellDone [ ]

Signature of the Instructor Date of Completion

Assignment Number:- 5
Title: DFA -driver
Ready Reference:
Topic:

A **finite state machine** (**FSM**) or **finite automaton** (plural: *automata*), is a model of behavior composed of a finite number of states, transitions between those states, and actions.

It is similar to a "flow graph" where we can inspect the way in which the logic runs when certain conditions are met.

A finite state machine is an abstract model of a machine with a primitive (sometimes read-only) internal memory.

In the theory of computation, a **deterministic finite automaton** (**DFA**)—is a finite state machine, where for each pair of state and input symbol; there is one and only one transition to a next state.

DFAs recognize the set of regular languages, and no other languages.

A DFA will take in, a string of input symbols. For each input symbol, it will then transit to a state, given by, following a transition function. When the last input symbol has been received, it will either accept or reject the string, depending on whether the DFA is in an accepting state or a non-accepting state.

Introduction

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In the theory of computation, a **deterministic finite automaton** (**DFA**)—is a finite state machine, where for each pair of state and input symbol; there is one and only one transition to a next state.

DFA’s recognize the set of regular languages, and no other languages.

A DFA will take in, a string of input symbols. For each input symbol, it will then transit to a state, given by, following a transition function. When the last input symbol has been received, it will either accept or reject the string, depending on whether the DFA is in an accepting state or a non-accepting state.

Formal definition

A DFA is a 5-tuple , (q, Σ, δ, q0, f), consisting of

- A finite set of states (q)
- A finite set of input symbols called the alphabet (Σ)
- A transition function ($\delta : q \times \Sigma \rightarrow q$)
- A start state (q0)
- A set of accept states ($f \subseteq q$)

Working

Let m be a DFA such that m = (q, Σ, δ, q_0, f), and $x = x_0x_1 \ldots X_{n-1}$ be a string over the alphabet Σ. M accepts the string x if a sequence of states, $r_0, r_1, \ldots, r_n$, exists in q with the following conditions:

1. $r_0 = q_0$
2. $r_{i+1} = \delta(r_i, x_i)$, for $i = 0, \ldots, n-1$

3. $r_n \in f$.

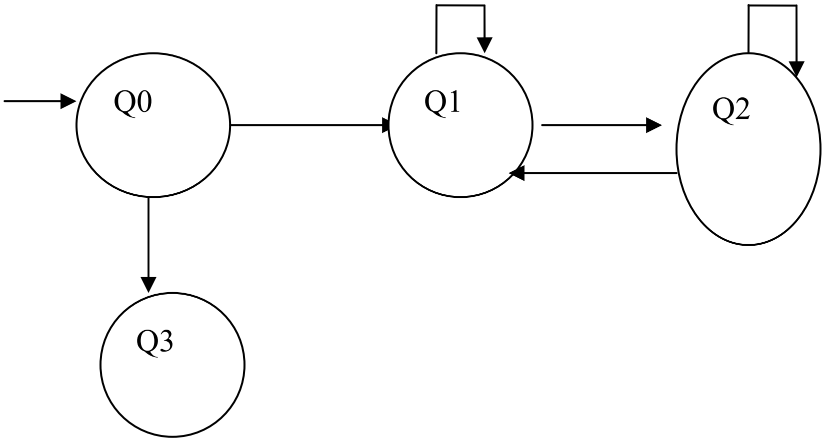
In words,

- The first condition says that the machine starts in the start state q_0.
- The second condition says that given each character of string x, the machine will transit from state to state, according to the transition function δ.
- The last condition says that, the machine accepts x if the last input of x causes the machine to halt in one of the accepting states. Otherwise, it is said that the automaton rejects the string.

The set of strings, the DFA accepts form a language, which is the language the DFA, recognizes.

Example

Construct a DFA for a language Lover {a, b} such that string should start with 'a' and ends with 'b'.



The above transition diagram can be represented in form of DFA tuple as follows:
Q = {q_0, q1, q2, q3}
∑ = {a, b}

$\delta = Q \times \sum = Q$

where

Δ	a	b
q_0	q1	q_3
q1	q1	q2
q2	q1	q2
q3	q_3	q_3

q_0 = initial state
F = {q2}

How to validate a string?

Example 1 : Validate string ababb

Currentstate	Currentinputsymbol	Transition Δ(currentstate, currentinputsymbol)	Updated currentstate
Q0	a	Q1	Q1
Q1	b	Q2	Q2
Q2	a	Q1	Q1
Q1	b	Q2	Q2
Q2	b	Q2	Q2

As value of currentstate, after string termination is q2, & q2 belongs to final state, string is valid.

Example 2 : validate string ababba

Currentstate	Currentinputsymbol	Transition Δ(currentstate, currentinputsymbol)	Updated currentstate

Q0	a	Q1	Q1
Q1	b	Q2	Q2
Q2	a	Q1	Q1
Q1	b	Q2	Q2
Q2	b	Q2	Q2
Q2	a	Q1	Q1

As value of currentstate, after string termination is q1, & q1 does not belong to final state, string is invalid.

Algorithm to implement DFA driver :

Input :

1. Number of states
2. Number of input symbols
3. Character array to store input symbols
4. Initial state
5. Number of final states
6. Array to store final states
7. 2 dimensional array transition (with dimension number of states x input symbols) to store states
8. Teststring to be validated

Output: DFA always give boolean output : yes, if string is acceted by DFA, no otherwise

Procedure :

1. Accept all the required input data
2. Let currentstate = initialstate
3. Traverse the entire string by scanning one character at a time.
4. Update currentstate by finding transition of current character of teststring from currentstate.
5. Repeat step 4 till the end of the string.
6. Lastly, if currentstate belongs to array of final states, string is valid, else invalid.

Set a :

1. Implement DFA driver for following languages :

(a) L = { set of all strings over {0, 1, 2} which start with 0 and contains substring 102 }
(b) L = { set of all strings over {x, y, z} which start with xy, end with zz and does not contain substring zxx }
(c) L = { set of all strings over {0, 1} which contain even number of 0's and odd number of 1's }

Set b:

1. Implement DFA driver with all validation checks.

Assignment Evaluation

0:Not Done [ ] 1:Incomplete [ ] 2.Late Complete [ ]
3:Needs Improvement [ ] 4:Complete [ ] 5:WellDone [ ]

Signature of the Instructor Date of Completion