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Department Of Computer Engineering

Microprocessor Lab Experiments

SUBMITTED TO THE DEPARTMENT OF COMPUTER ENGINEERING
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SE COMPTER ENGINEERING

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EXPERIMENT NO. 01

NAME: Content to bridge the GAP- Write an X86/64 ALP to display Hello World using macros.

AIM: : Write an X86/64 ALP to display Hello World using Macros.

OBJECTIVES:

- To understand assembly language programming instruction set
- To understand different assembler directives with example
- To apply instruction set for implementing X86/64 bit assembly language programs

ENVIRONMENT:

- Operating System: 64-bit Open source Linux or its derivative.
- Programming Tools: Preferably using Linux equivalent or MASM/TASM/NASM/FASM.
- Text Editor: geditor

THEORY:

Introduction to Assembly Language Programming:

Each personal computer has a microprocessor that manages the computer's arithmetical, logical and control activities. Each family of processors has its own set of instructions for handling various operations like getting input from keyboard, displaying information on screen and performing various other jobs. These set of instructions are called 'machine language instruction'. Processor understands only machine language instructions which are strings of 1s and 0s. However machine language is too obscure and complex for using in software development. So the low level assembly language is designed for a specific family of processors that represents various instructions in symbolic code and a more understandable form. Assembly language is a low-level programming language for a computer, or other programmable device specific to particular computer architecture in contrast to most high-level programming languages, which are generally portable across multiple systems. Assembly language is converted into executable machine code by a utility program referred to as an assembler like NASM, MASM etc.

MACROS:

Writing a macro is another way of ensuring modular programming in assembly language.

- A macro is a sequence of instructions, assigned by a name and could be used anywhere in the program.
- In NASM, macros are defined with **%macro** and **%endmacro** directives.
- The macro begins with the %macro directive and ends with the %endmacro directive.

The Syntax for macro definition –

```
%macro macro_name  number_of_params
<macro body>
%endmacro
```

Where, *number_of_params* specifies the number parameters, *macro_name* specifies the name of the macro.

The macro is invoked by using the macro name along with the necessary parameters. When you need to use some sequence of instructions many times in a program, you can put those instructions in a macro and use it instead of writing the instructions all the time.

For example, a very common need for programs is to write a string of characters in the screen. For displaying a string of characters, you need the following sequence of instructions –

```
mov    edx,len           ;message length
mov    ecx,msg           ;message to write
mov    ebx,1        ;file descriptor (stdout)
mov    eax,4        ;system call number (sys_write)
int    0x80         ;call kernel
```

In the above example of displaying a character string, the registers EAX, EBX, ECX and EDX have been used by the INT 80H function call. So, each time you need to display on screen, you need to save these registers on the stack, invoke INT 80H and then restore the original value of the registers from the stack. So, it could be useful to write two macros for saving and restoring data.

We have observed that, some instructions like IMUL, IDIV, INT, etc., need some of the information to be stored in some particular registers and even return values in some specific register(s). If the program was already using those registers for keeping important data, then the existing data from these registers should be saved in the stack and restored after the instruction is executed.

ALGORITHM:

Editing, Assembling, Linking and Executing First Program : hello.asm

1. Boot the machine with ubuntu
2. Select and click on <dash home> icon from the toolbar.
3. Start typing "terminal".
4. Click on "terminal" icon. A terminal window will open showing command prompt.
5. Give the following command at the prompt to invoke the editor gedit hello.asm

[3:55 PM, 6/6/2021] Akash Mete: 6. Type in the program in gedit window, save and exit

7. To assemble the program write the command at the prompt as follows and press enter key

nasm -f elf32 hello.asm -o hello.o (for 32 bit)

nasm -f elf64 hello.asm -o hello.o (for 64 bit)

8. If the execution is error free, it implies hello.o object file as been created.
9. To link and create the executable give the command as

ld -o hello hello.o

10. To execute the program write at the prompt

./hello

11. Hello, world will be displayed at the prompt.

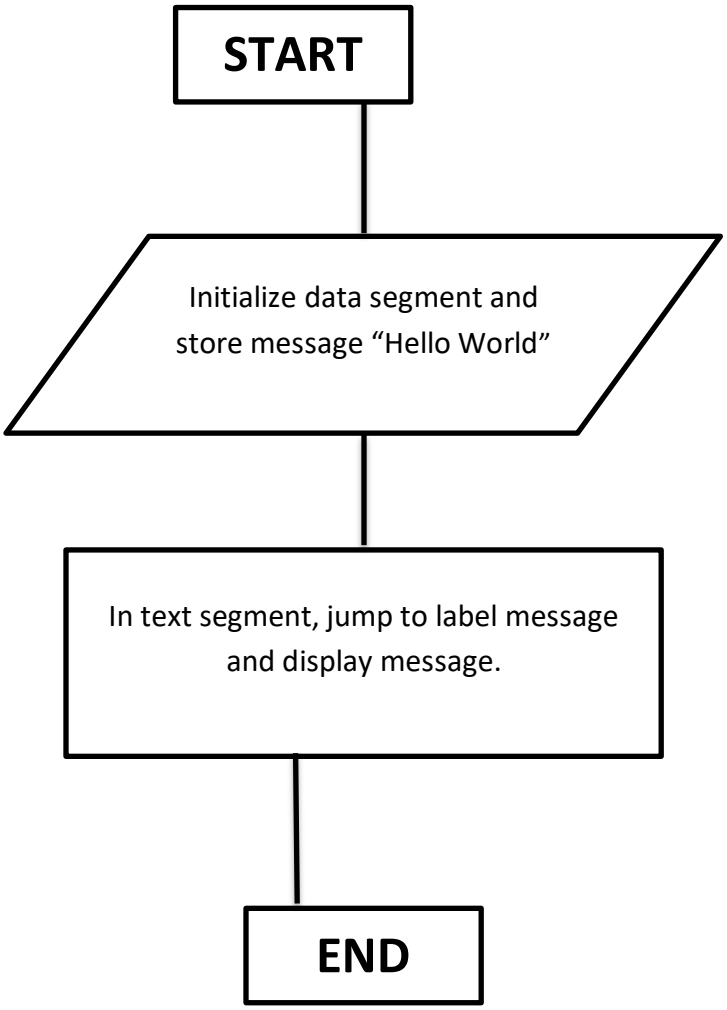
PROGRAM:

ALP to Print "Hello World" using 64-bit model

```
section data
message: db 'Hello, world', Ox0A ; message and newline
length: equ
$-message
; length of message string
section text
global_start
; global entry point export for ld
start:
```

```
mov
rax, 1
mov rdi, 1
mov rsi, message
mov rdx, length
syscall
; 01 specifies sys write kemel call
; 01 specifies stdout
: Load starting address of message into rsi
; Load message string length into rdx
mov
rax, 60
mov
; sys_exit
rdi, o
; return 0 (success)
Syscall
```

FLOWCHART:



CONCLUSION:

In this practical session we learnt how to display Hello World using macros.

EXPERIMENT NO. 02

NAME: Write an X86/64 ALP to accept five 64 bit Hexadecimal numbers from user and store them in an array and display the accepted numbers.

AIM: : Write an X86/64 ALP to accept five 64 bit Hexadecimal numbers from user and store them in an array and display the accepted numbers.

OBJECTIVES:

- To understand assembly language programming instruction set
- To understand different assembler directives with example
- To apply instruction set for implementing X86/64 bit assembly language programs

ENVIRONMENT:

- Operating System: 64-bit Open source Linux or its derivative.
- Programming Tools: Preferably using Linux equivalent or MASM/TASM/NASM/FASM.
- Text Editor: geditor

THEORY:

Introduction to Assembly Language Programming:

Each personal computer has a microprocessor that manages the computer's arithmetical, logical and control activities. Each family of processors has its own set of instructions for handling various operations like getting input from keyboard, displaying information on screen and performing various other jobs. These set of instructions are called 'machine language instruction'. Processor understands only machine language instructions which are strings of 1s and 0s. However machine language is too obscure and complex for using in software development. So the low level assembly language is designed for a specific family of processors that represents various instructions in symbolic code and a more understandable form. Assembly language is a low-level programming language for a computer, or other programmable device specific to particular computer architecture in contrast to most high-level programming languages, which are generally portable across multiple systems. Assembly language is converted into executable machine code by a utility program referred to as an assembler like NASM, MASM etc.

Advantages of Assembly Language

 An understanding of assembly language provides knowledge of:
 Interface of programs with OS, processor and BIOS;
 Representation of data in memory and other external devices;
 How processor accesses and executes instruction;
 How instructions accesses and process data;
 How a program access external devices.

Other advantages of using assembly language are:
 It requires less memory and execution time;
 It allows hardware-specific complex jobs in an easier way;
 It is suitable for time-critical jobs;

ALP Step By Step:

Installing NASM:

If you select "Development Tools" while installed Linux, you may NASM installed along with the Linux operating system and you do not need to download and install it separately. For checking whether you already have NASM installed, take the following steps:
 Open a Linux terminal.
 Type ***whereis nasm*** and press ENTER.
 If it is already installed then a line like, *nasm: /usr/bin/nasm* appears. Otherwise, you will see just*nasm:*, then you need to install NASM.

To install NASM take the following steps:

Open Terminal and run below commands:
sudo apt-get update
sudo apt-get install nasm

Assembly Basic Syntax:
An assembly program can be divided into three sections:
 The **data** section
 The **bss** section
 The **text** section

The order in which these sections fall in your program really isn't important, but by convention the .data section comes first, followed by the .bss section, and then the .text section.

The .data Section
The .data section contains data definitions of initialized data items. Initialized data is data that has a value before the program begins running. These values are part of the executable file. They are loaded into memory when the executable file is loaded into memory for execution. You don't have to load them with their values, and no machine cycles are used in their creation beyond what it takes to load the

program as a whole into memory. The important thing to remember about the .data section is that the more initialized data items you define, the larger the executable file will be, and the longer it will take to load it from disk into memory when you run it.

The .bss Section

Not all data items need to have values before the program begins running. When you're reading data from a disk file, for example, you need to have a place for the data to go after it comes in from disk. Data buffers like that are defined in the .bss section of your program. You set aside some number of bytes for a buffer and give the buffer a name, but you don't say what values are to be present in the buffer. There's a crucial difference between data items defined in the .data section and data items defined in the .bss section: data items in the .data section add to the size of your executable file. Data items in the .bss section do not.

The .text Section

The actual machine instructions that make up your program go into the .text section. Ordinarily, no data items are defined in .text. The .text section contains symbols called *labels* that identify locations in the program code for jumps and calls, but beyond your instruction mnemonics, that's about it.
All global labels must be declared in the .text section, or the labels cannot be ''seen'' outside your program by the Linux linker or the Linux loader. Let's look at the labels issue a little more closely.

Labels

A label is a sort of bookmark, describing a place in the program code and giving it a name that's easier to remember than a naked memory address. Labels are used to indicate the places where jump instructions should jump to, and they give names to callable assembly language procedures.
Here are the most important things to know about labels:
 Labels must begin with a letter, or else with an underscore, period, or question mark. These last three have special meanings to the assembler, so don't use them until you know how NASM interprets them.
 Labels must be followed by a colon when they are defined. This is basically what tells NASM that the identifier being defined is a label. NASM will punt if no colon is there and will not flag an error, but the colon nails it, and prevents a mistyped instruction mnemonic from being mistaken for a label. Use the colon!
 Labels are case sensitive. So yikes:, Yikes:, and YIKES: are three completely different labels.

Assembly Language Statements

Assembly language programs consist of three types of statements:
 Executable instructions or instructions
 Assembler directives or pseudo-ops
 Macros

Syntax of Assembly Language Statements

[label] mnemonic [operands] [;comment]

LIST OF INTERRRUPTS USED: NA

LIST OF ASSEMBLER DIRECTIVES USED: EQU,DB

LIST OF MACROS USED: NA

LIST OF PROCEDURES USED: NA

ALGORITHM:

INPUT: ARRAY

OUTPUT: ARRAY

STEP 1: Start.

STEP 2: Initialize the data segment.

STEP 3: Display msg1 “Accept array from user. “

STEP 4: Initialize counter to 05 and rbx as 00

STEP 5: Store element in array.

STEP 6: Move rdx by 17.

STEP 7: Add 17 to rbx.

STEP 8: Decrement Counter.

STEP 9: Jump to step 5 until counter value is not zero.

STEP 9: Display msg2.

STEP 10: Initialize counter to 05 and rbx as 00

STEP 11: Display element of array.

STEP 12: Move rdx by 17.

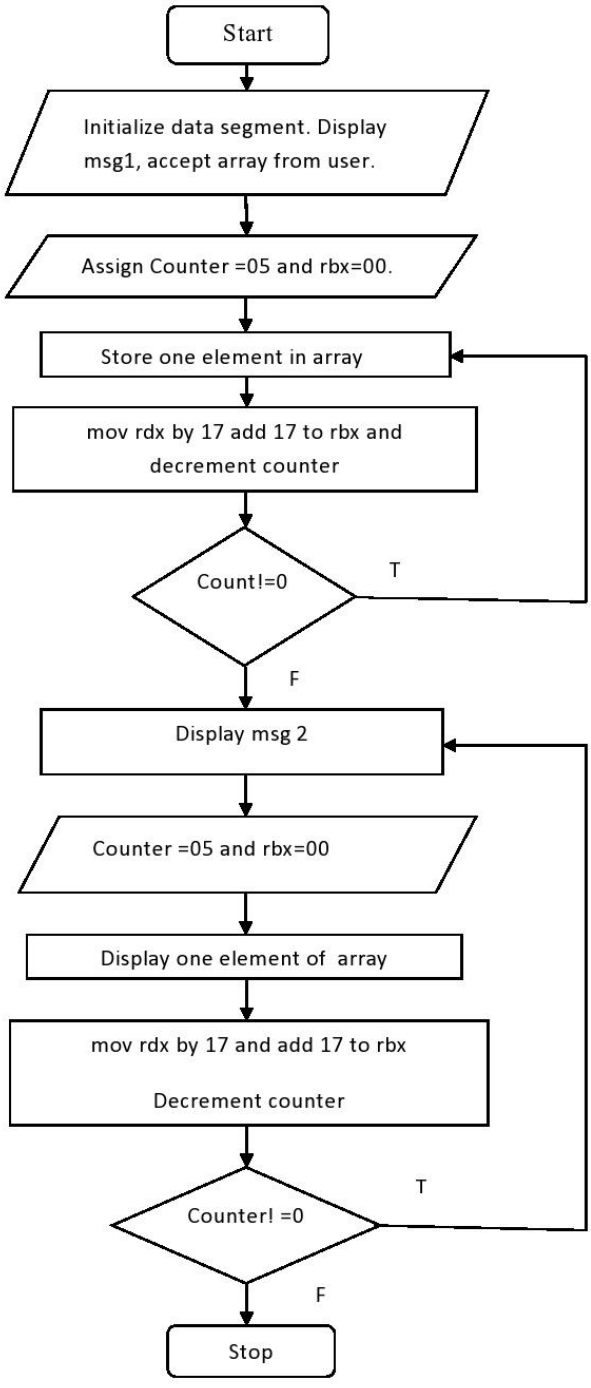
STEP 13: Add 17 to rbx.

STEP 14: Decrement Counter.

STEP 15: Jump to step 11 until counter value is not zero.

STEP 16: Stop

FLOWCHART:


Start
Initialize data segment. Display msg1, accept array from user.
Assign Counter =05 and rbx=00.
Store one element in array
mov rdx by 17 add 17 to rbx and decrement counter
Count!=0
T
F
Display msg 2
Counter =05 and rbx=00
Display one element of array
mov rdx by 17 and add 17 to rbx
Decrement counter
Counter! =0
T
F
Stop

PROGRAM:

```
section .data
        msg1 db 10,13,"Enter 5 64 bit numbers"
        len1 equ $-msg1
        msg2 db 10,13,"Entered 5 64 bit numbers"
        len2 equ $-msg2
section .bss
        array resd 200
        counter resb 1
section .text
        global _start
        _start:
;display
        mov Rax,1
        mov Rdi,1
        mov Rsi,msg1
        mov Rdx,len1
        syscall
;accept
mov byte[counter],05
mov rbx,00
                loop1:
                        mov rax,0               ; 0 for read
                        mov rdi,0               ; 0 for keyboard
                        mov rsi, array          ;move pointer to start of array
                        add rsi,rbx
                        mov rdx,17
                        syscall
                add rbx,17              ;to move counter
                        dec byte[counter]
                        JNZ loop1
;display
        mov Rax,1
        mov Rdi,1
        mov Rsi,msg2
        mov Rdx,len2
        syscall
;display
mov byte[counter],05
mov rbx,00
                loop2:
                        mov rax,1               ;1 for write
                        mov rdi, 1              ;1 for monitor
                        mov rsi, array
                        add rsi,rbx
                        mov rdx,17              ;16 bit +1 for enter
                        syscall
                        add rbx,17
                        dec byte[counter]
                        JNZ loop2
                ;exit system call
```

```
                mov rax ,60
                mov rdi,0
                syscall
;output
;vacoea@vacoea-Pegatron:~$ cd ~/Desktop
;vacoea@vacoea-Pegatron:~/Desktop$ nasm -f elf64 ass1.asm
;vacoea@vacoea-Pegatron:~/Desktop$ ld -o ass1 ass1.o
;vacoea@vacoea-Pegatron:~/Desktop$ ./ass1

;Enter 5 64 bit numbers12
;23
;34
;45
;56

;Entered 5 64 bit numbers12
;23
;34
;45
;56
```

CONCLUSION:

In this practical session we learnt how to write assembly language program and Accept and display array in assembly language.

EXPERIMENT NO. 03

NAME: Write an X86/64 ALP to accept a string and to display its length.

AIM: Write an X86/64 ALP to accept a string and to display its length.

OBJECTIVES:

- To understand assembly language programming instruction set.
- To understand different assembler directives with example.
- To apply instruction set for implementing X86/64 bit assembly language programs

ENVIRONMENT:

- Operating System: 64-bit Open source Linux or its derivative.
- Programming Tools: Preferably using Linux equivalent or MASM/TASM/NASM/FASM.
- Text Editor: geditor

THEORY:

MACRO:

Writing a macro is another way of ensuring modular programming in assembly language.

- A macro is a sequence of instructions, assigned by a name and could be used anywhere in the program.
- In NASM, macros are defined with **%macro** and **%endmacro** directives.
- The macro begins with the %macro directive and ends with the %endmacro directive.

The Syntax for macro definition −

```
%macro macro_name  number_of_params
<macro body>
%endmacro
```

Where, *number_of_params* specifies the number parameters, *macro_name* specifies the name of the macro.

The macro is invoked by using the macro name along with the necessary parameters. When you need to use some sequence of instructions many times in a program, you can put those instructions in a macro and use it instead of writing the instructions all the time.

PROCEDURE:

Procedures or subroutines are very important in assembly language, as the assembly language programs tend to be large in size. Procedures are identified by a name. Following this name, the body of the procedure is described which performs a well-defined job. End of the procedure is indicated by a return statement.

Syntax

Following is the syntax to define a procedure −

```
proc_name:
   procedure body
   ...
   ret
```

The procedure is called from another function by using the CALL instruction. The CALL instruction should have the name of the called procedure as an argument as shown below −

CALL proc_name

The called procedure returns the control to the calling procedure by using the RET instruction.

LIST OF INTERRRUPTS USED: NA

LIST OF ASSEMBLER DIRECTIVES USED: EQU, PROC, GLOBAL, DB,

LIST OF MACROS USED: DISPMSG

LIST OF PROCEDURES USED: DISPLAY

ALGORITHM:

INPUT: String

OUTPUT: Length of String in hex

STEP 1: Start.

STEP 2: Initialize data section.

STEP 3: Display msg1 on monitor

STEP 4: accept string from user and store it in Rsi Register (Its length gets stored in Rax register by default).

STEP 5: Display the result using “display” procedure. Load length of string in data register.

STEP 6. Take counter as 16 int cnt variable

STEP 7: move address of “result” variable into rdi.

STEP 8: Rotate left rbx register by 4 bit.

STEP 9: Move bl into al.

STEP 10: And al with 0fh

STEP 11: Compare al with 09h

STEP 12: If greater add 37h into al

STEP 13: else add 30h into al

STEP 14: Move al into memory location pointed by rdi

STEP 14: Increment rdi

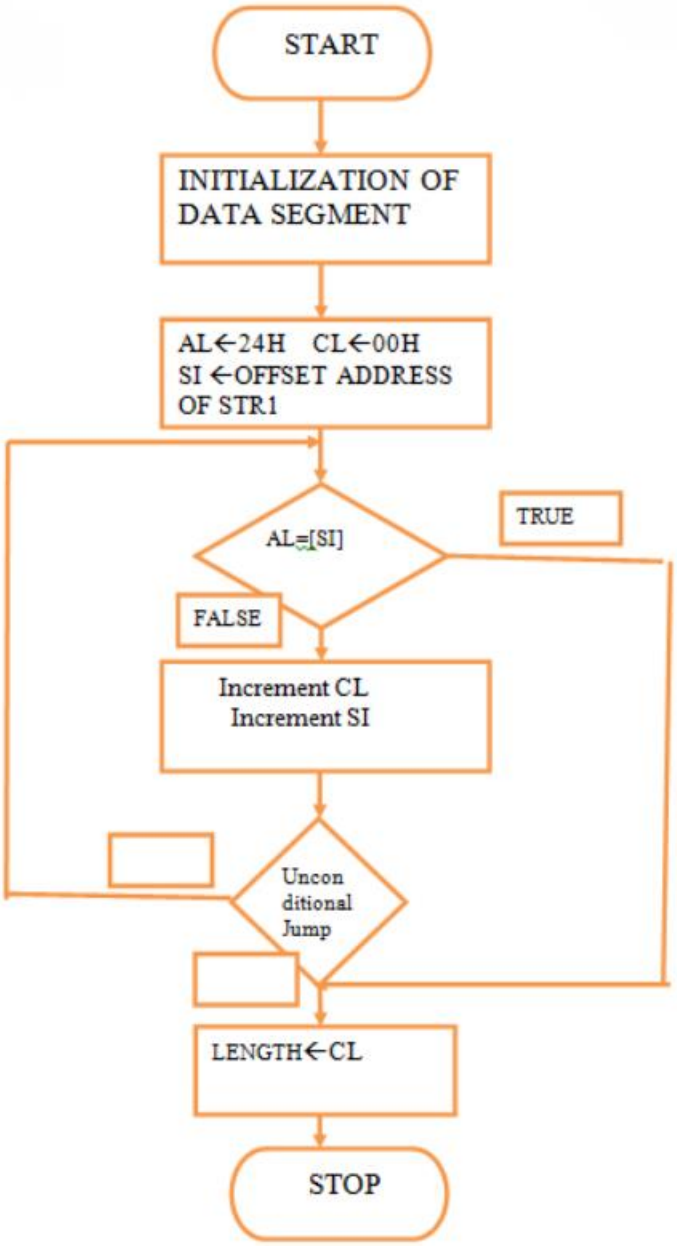
STEP 15: Loop the statement till counter value becomes zero

STEP 16: Call macro dispmsg and pass result variable and length to it. It will print length of string.

STEP 17: Return from procedure

STEP 18: Stop

FLOWCHART:


START
INITIALIZATION OF DATA SEGMENT
AL←24H CL←00H
SI ←OFFSET ADDRESS OF STR1
AL=[SI]
TRUE
FALSE
Increment CL
Increment SI
Uncon ditional Jump
LENGTH←CL
STOP

PROGRAM:

```
section .data
        msg1 db 10,13,"Enter a string:"
        len1 equ $-msg1

section .bss
        str1 resb 200           ;string declaration
        result resb 16

section .text

global _start
        _start:

;display
        mov Rax,1
        mov Rdi,1
        mov Rsi,msg1
        mov Rdx,len1
        syscall

;store string

        mov rax,0
        mov rdi,0
        mov rsi,str1
        mov rdx,200
        syscall

call display

;exit system call
        mov Rax ,60
        mov Rdi,0
        syscall


%macro dispmsg 2
        mov Rax,1
        mov Rdi,1
        mov rsi,%1
        mov rdx,%2
        syscall
%endmacro



display:
        mov rbx,rax             ; store no in rbx
        mov rdi,result          ;point rdi to result variable
        mov cx,16               ;load count of rotation in cl
```

```
        up1:
                rol rbx,04              ;rotate no of left by four bits
                mov al,bl                   ; move lower byte in al
                and al,0fh              ;get only LSB
                cmp al,09h               ;compare with 39h
                jg add_37               ;if greater than 39h skip add 37
                add al,30h
                jmp skip                ;else add 30
        add_37:
                add al,37h
        skip:
                mov [rdi],al             ;store ascii code in result variable
                inc rdi                ; point to next byte
                dec cx                  ; decrement counter
                jnz up1                 ; if not zero jump to repeat
                dispmsg result,16       ;call to macro
ret
```

CONCLUSION:

In this practical session we learnt how to accept string and display its length.

EXPERIMENT NO. 04

NAME: Write an X86/64 ALP to count number of positive and negative numbers from the array.

AIM: Write an X86/64 ALP to count number of positive and negative numbers from the array.

OBJECTIVES:

- To understand assembly language programming instruction set.
- To understand different assembler directives with example.
- To apply instruction set for implementing X86/64 bit assembly language programs

ENVIRONMENT:

- Operating System: 64-bit Open source Linux or its derivative.
- Programming Tools: Preferably using Linux equivalent or MASM/TASM/NASM/FASM.
- Text Editor: geditor

THEORY:

Mathematical numbers are generally made up of a sign and a value (magnitude) in which the sign indicates whether the number is positive, (+) or negative, (–) with the value indicating the size of the number, for example 23, +156 or -274. Presenting numbers is this fashion is called "sign-magnitude" representation since the left most digit can be used to indicate the sign and the remaining digits the magnitude or value of the number.

Sign-magnitude notation is the simplest and one of the most common methods of representing positive and negative numbers either side of zero, (0). Thus negative numbers are obtained simply by changing the sign of the corresponding positive number as each positive or unsigned number will have a signed opposite, for example, +2 and -2, +10 and -10, etc.

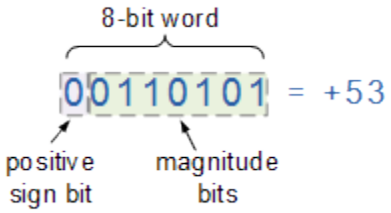
But how do we represent signed binary numbers if all we have is a bunch of one's and zero's. We know that binary digits, or bits only have two values, either a "1" or a "0" and conveniently for us, a sign also has only two values, being a "**+**" or a "**–**".

Then we can use a single bit to identify the sign of a *signed binary number* as being positive or negative in value. So to represent a positive binary number (+n) and a negative (-n) binary number, we can use them with the addition of a sign.

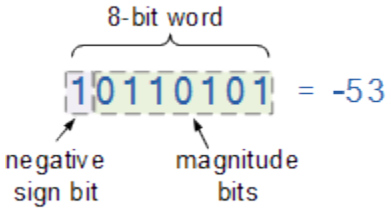
For signed binary numbers the most significant bit (MSB) is used as the sign bit. If the sign bit is "0", this means the number is positive in value. If the sign bit is "1", then the number is negative in value. The remaining bits in the number are used to represent the magnitude of the binary number in the usual unsigned binary number format way.

Then we can see that the Sign-and-Magnitude (SM) notation stores positive and negative values by dividing the "n" total bits into two parts: 1 bit for the sign and n–1 bits for the value which is a pure binary number. For example, the decimal number 53 can be expressed as an 8-bit signed binary number as follows.

Positive Signed Binary Numbers



Negative Signed Binary Numbers



LIST OF INTERRRUPTS USED: 80h

LIST OF ASSEMBLER DIRECTIVES USED: equ, db

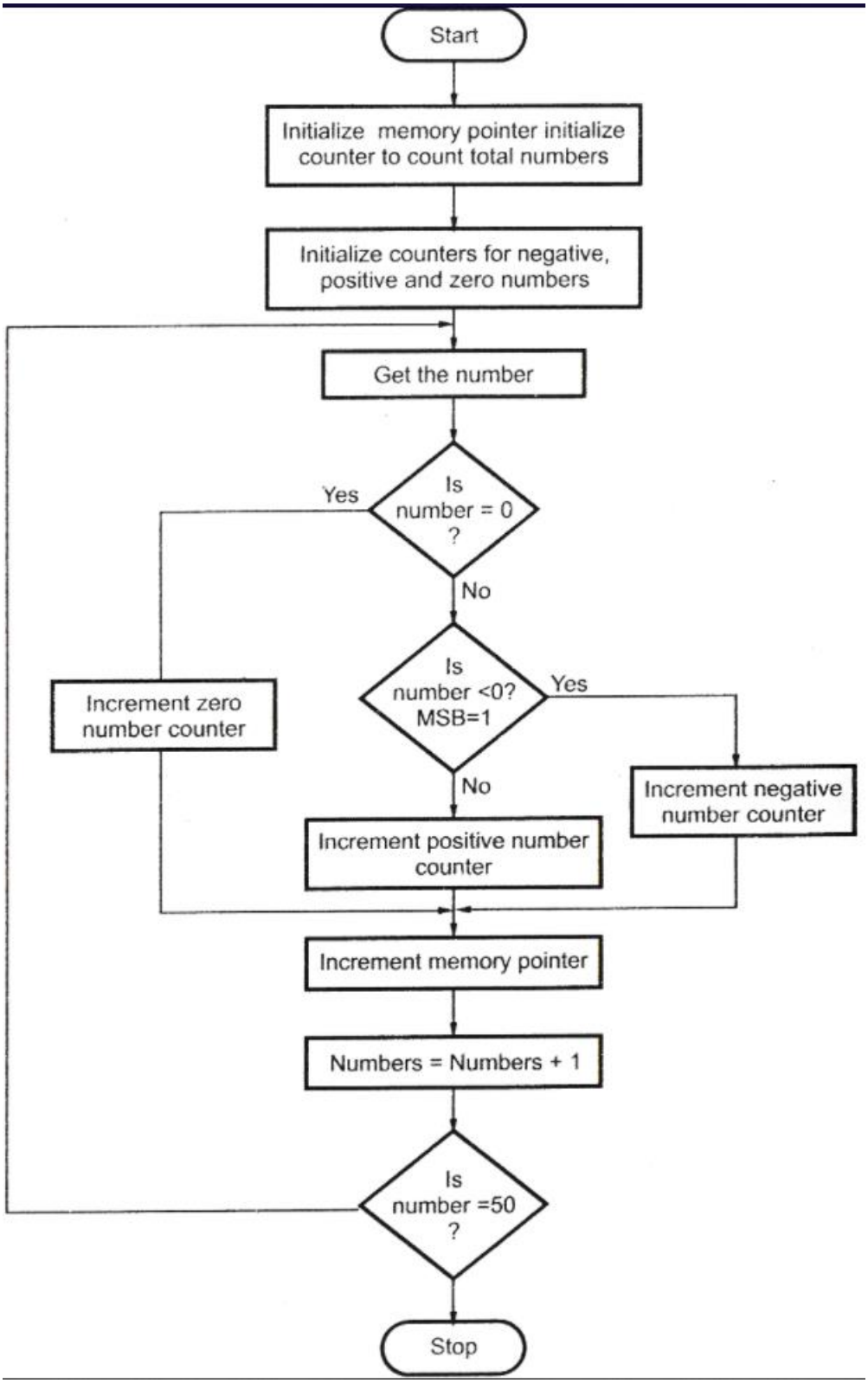
LIST OF MACROS USED: print

LIST OF PROCEDURES USED: disp8num

ALGORITHM:

STEP 1: Initialize index register with the offset of array of signed numbers
STEP 2: Initialize ECX with array element count
STEP 3: Initialize positive number count and negative number count to zero
STEP 4: Perform MSB test of array element
STEP 5: If set jump to step 7
STEP 6: Else Increment positive number count and jump to step 8
STEP 7: Increment negative number count and continue
STEP 8: Point index register to the next element
STEP 9: Decrement the array element count from ECX, if not zero jump to step 4, else continue
STEP 10: Display Positive number message and then display positive number count
STEP 11: Display Negative number message and then display negative number count
STEP 12: EXIT

FLOWCHART:


Start
Initialize memory pointer initialize counter to count total numbers
Initialize counters for negative, positive and zero numbers
Get the number
Is number = 0 ?
Yes
No
Is number <0? MSB=1
Yes
No
Increment zero number counter
Increment negative number counter
Increment positive number counter
Increment memory pointer
Numbers = Numbers + 1
Is number =50 ?
Stop

PROGRAM:

```
;Write an ALP to count no. of positive and negative numbers from the array.

section .data

welmsg db 10,'Welcome to count positive and negative numbers in an array',10
welmsg_len equ $-welmsg

pmsg db 10,'Count of +ve numbers::'
pmsg_len equ $-pmsg

nmsg db 10,'Count of -ve numbers::'
nmsg_len equ $-nmsg

nwline db 10

array dw 8505h,90ffh,87h,88h,8a9fh,0adh,02h,8507h

arrcnt equ 8

pcnt db 0
ncnt db 0

section .bss
        dispbuff resb 2

%macro print 2              ;defining print function
        mov eax, 4          ; this 4 commands signifies the print sequence
        mov ebx, 1
        mov ecx, %1         ; first parameter
        mov edx, %2         ;second parameter
        int 80h             ;interrupt command
%endmacro

section .text               ;code segment
        global _start       ;must be declared for linker
        _start:         ;tells linker the entry point ;i.e start of code
        print welmsg,welmsg_len   ;print title
        mov esi,array
        mov ecx,arrcnt      ;store array count in extended counter reg


        up1:                ;label
                bt word[esi],15
                ;bit test the array number (15th byte) pointed by esi.
                ;It sets the carray flag as the bit tested
                jnc pnxt    ;jump if no carry to label pskip

                inc byte[ncnt]   ;if the 15th bit is 1 it signifies it is a ;negative no and so we ;use this command to
                increment ncnt counter.
                jmp pskip       ;unconditional jump to label skip
```

```
            pnxt: inc byte[pcnt]    ;label pnxt if there no carry then it is ;positive no
            ;and so pcnt is incremented
            pskip: inc esi          ;increment the source index but this ;instruction only increments it by 8 bit but
            the no's in array ;are 16 bit word and hence it needs to be incremented twice.

            inc esi
            loop up1        ;loop it ends as soon as the array end "count" or

            ;ecx=0 loop automatically assums ecx has the counter

        print pmsg,pmsg_len      ;prints pmsg
        mov bl,[pcnt]    ;move the positive no count  to lower 8 bit of B reg
        call disp8num            ;call disp8num subroutine
        print nmsg,nmsg_len         ;prints nmsg
        mov bl,[ncnt]    ;move the negative no count to lower 8 bits of b reg
        call disp8num        ;call disp8num subroutine


        print nwline,1        ;New line char

        exit:
            mov eax,01
            mov ebx,0
            int 80h

        disp8num:
            mov ecx,2        ;move 2 in ecx ;Number digits to display
            mov edi,dispbuff              ;Temp buffer

            dup1:      ;this command sequence which converts hex to bcd
            rol bl,4              ;Rotate number from bl to get MS digit to LS digit
            mov al,bl         ;Move  bl i.e. rotated number to AL
            and al,0fh          ;Mask upper digit (logical AND the contents ;of lower8 bits of accumulator with
            0fh )

            cmp al,09         ;Compare al with 9

    jbe dskip      ;If number below or equal to 9 go to add only 30h
            ;add al,07h ;Else first add 07h to accumulator

        dskip:
    add al,30h        ;Add 30h to accumulator
         mov [edi],al          ;Store ASCII code in temp buff (move contents       ;of accumulator to the location
pointed by edi)
         inc edi
                        ;Increment destination index i.e. pointer to      ;next location in temp buff
        loop dup1         ;repeat till ecx becomes zero

        print dispbuff,2         ;display the value from temp buff
        ret                  ;return to calling program
```

OUTPUT:

```
;[root@comppl2022 ~]# nasm -f elf64 Exp5.asm
;[root@comppl2022 ~]# ld -o Exp6 Exp5.o
;[root@comppl2022 ~]# ./Exp5
;Welcome to count +ve and -ve numbers in an array
;Count of +ve numbers::05
;Count of -ve numbers::03
;[root@comppl2022 ~]#
```

CONCLUSION:

In this practical session we learnt to count number of positive and negative numbers from the array.

EXPERIMENT NO. 05

NAME: Write an X86/64 ALP to find the largest of given Byte/Word/Dword/64-bit numbers

AIM: Write an X86/64 ALP to find the largest of given Byte/Word/Dword/64-bit numbers

OBJECTIVES:

- To understand assembly language programming instruction set.
- To understand different assembler directives with example.
- To apply instruction set for implementing X86/64 bit assembly language programs

ENVIRONMENT:

- Operating System: 64-bit Open source Linux or its derivative.
- Programming Tools: Preferably using Linux equivalent or MASM/TASM/NASM/FASM.
- Text Editor: geditor

THEORY:

Datatype in 80386:

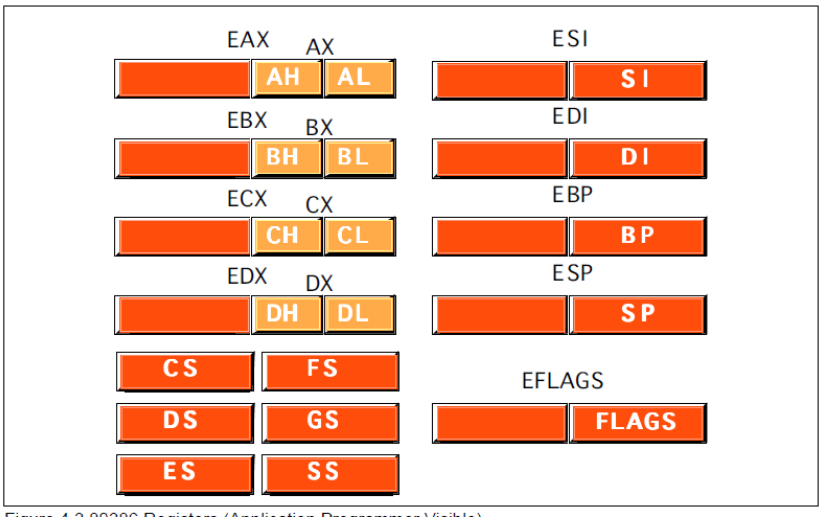
Datatypes of 80386:

The 80386 supports the following data types they are

- Bit
- Bit Field: A group of at the most 32 bits (4bytes)
- Bit String: A string of contiguous bits of maximum 4Gbytes in length.
- Signed Byte: Signed byte data
- Unsigned Byte: Unsigned byte data.
- Integer word: Signed 16-bit data.
- Long Integer: 32-bit signed data represented in 2's complement form.
- Unsigned Integer Word: Unsigned 16-bit data
- Unsigned Long Integer: Unsigned 32-bit data
- Signed Quad Word: A signed 64-bit data or four word data.
- Unsigned Quad Word: An unsigned 64-bit data.
- Offset: 16/32-bit displacement that points a memory location using any of the addressing modes.
- Pointer: This consists of a pair of 16-bit selector and 16/32-bit offset.

- Character: An ASCII equivalent to any of the alphanumeric or control characters.
- Strings: These are the sequences of bytes, words or double words. A string may contain minimum one byte and maximum 4 Gigabytes.
- BCD: Decimal digits from 0-9 represented by unpacked bytes.
- Packed BCD: This represents two packed BCD digits using a byte, i.e. from 00 to 99.

Registers in 80386:



- General Purpose Register: EAX, EBX, ECX, EDX
- Pointer register: ESP, EBP
- Index register: ESI, EDI
- Segment Register: CS, FS, DS, GS, ES, SS
- Eflags register: EFLAGS
- System Address/Memory management Registers : GDTR, LDTR, IDTR
- Control Register: Cr0, Cr1, Cr2, Cr3
- Debug Register : DR0, DR,1 DR2, DR3, DR4, DR5, DR6, DR7
- Test Register: TR0, TR,1 TR2, TR3, TR4, TR5, TR6, TR7

EAX	AX	AH,AL
EBX	BX	BH,BL
ECX	CX	CH,CL
EDX	DX	DH,DL

EBP	BP	
EDI	DI	
ESI	SI	
ESP		

Size of operands in an Intel assembler instruction

- Specifying the size of an operand in Intel
- The size of the operand (byte, word, double word) is conveyed by the operand itself
- EAX means: a 32 bit operand
- AX means: a 16 bit operand
- AL means: a 8 bit operand The size of the source operand and the destination operand must be equal

Addressing modes in 80386:

The purpose of using addressing modes is as follows:

1. To give the programming versatility to the user.
2. To reduce the number of bits in addressing field of instruction.

1. Register addressing mode:	MOV EAX, EDX
2. Immediate Addressing modes:	MOV ECX, 20305060H
3. Direct Addressing mode:	MOV AX, [1897 H]
4. Register Indirect Addressing mode	MOV EBX, [ECX]
5. Based Mode	MOV ESI, [EAX+23H]
6. Index Mode	SUB COUNT [EDI], EAX
7. Scaled Index Mode	MOV [ESI*8], ECX
8. Based Indexed Mode	MOV ESI, [ECX][EBX]
9. Based Index Mode with displacement	EA=EBX+EBP+1245678H
10. Based Scaled Index Mode with displacement	MOV [EBX*8] [ECX+5678H], ECX
11. String Addressing modes:	
12. Implied Addressing modes:	

ALGORITHM:

Step 1: Start.

Step 2: Initialize Block Size and get the address of first element.

Step 3: Load the data from the memory.

Step 4: Decrement Block Size and Increment address of first element.

Step 5: Store first element in A.

Step 6: Compare A with other elements, if A is smaller then store that element in B otherwise compare with next element.

Step 7: The value of B is the answer.

Step 8: Stop.

PROGRAM:

32 Bit NASM Code for Byte

```
%macro scall 4                                  ;macro declaration with 4
parameters
        mov eax,%1                              ;1st parameter has been moved to
eax
        mov ebx,%2                              ;2nd parameter has been moved to
ebx
        mov ecx,%3                              ;3rd parameter has been moved to
ecx
        mov edx,%4                              ;4th parameter has been moved to
edx
        int 80h                                 ;Call the Kernel
%endmacro                                       ;end of macro

section .data                                       ;.data segment begins here
        m1 db "Enter size of array: ",10d,13d   ;m1 initialised with a
string
        l1 equ $-m1                             ;l1 stores length of m1
string
        m2 db "Enter array elements: ",10d,13d  ;m2 initialised with a
string
        l2 equ $-m2                             ;l2 stores length of m2
string
        m3 db 10d,13d,"Largest: "               ;m3 initialised with a
string
        l3 equ $-m3                             ;l3 stores length of m3
string
```

```
        m4 db 10d,13d                   ;m4 initialised with a
string
        l4 equ $-m4                     ;l4 stores length of m4
string

section .bss                            ;.bss segment starts here
        cnt resb 3                      ;variable with 3 byte size
        arr resb 3                      ;variable with 3 byte size
        cnt1 resb 3                     ;variable with 3 byte size
        arr1 resb 50                    ;variable with 50 byte size
        temp resb 2                     ;variable with 2 byte size
        char_ans resb 2                 ;variable with 2 byte size

section .text                           ;.text segment starts here
        global _start                   ;declaring _start label as
global
_start:                                 ;_start label

        scall 4,1,m1,l1                 ;macro call to display m1
        scall 3,0,arr,3                 ;macro call to input in arr

        mov esi,arr                     ;esi points to arr
        call asciihextohex              ;calling procedure to
convert into hex nos

        mov byte[cnt],dl                ;moving values of dl into
cnt
        mov byte[cnt1],dl               ;moving values of dl into
cnt
        scall 4,1,m2,l2                 ;macro call to display m2
        mov edi,arr1                    ;edi points to arr1

back:   scall 3,0,arr,3                 ;macro call to input in arr
        mov esi,arr                     ;esi points to arr
        call asciihextohex              ;calling procedure to
convert into hex nos

        mov [edi],dl                    ;move contents of dl at
address of edi
        inc edi                         ;increment edi to point to
next element
        dec byte[cnt]                   ;decrement cnt variable
        jnz back                        ;jump if cnt is not zero to
back label

        mov esi,arr1                    ;esi points to arr1
        mov al,[esi]                    ;move contents at esi into
al
        inc esi                         ;increment esi to point to
next element

up1:    mov bl,[esi]                    ;move contents at esi into
bl
```

```
        cmp al,bl                       ;compare al with bl
        jg next1                        ;if al is greater, jump to
next1
        mov byte[temp],al               ;copying al into temp
        mov al,bl                       ;copying bl into al
        mov bl,byte[temp]               ;copying temp into bl
next1:  inc esi                         ;increment esi
        dec byte[cnt1]                  ;decrement cnt1
        jnz up1                         ;jump to up1, if cnt1 not
zero

        mov ecx,02                      ;copy 02 into ecx
        mov esi,char_ans                ;esi points to char_ans

up4:    rol al,4                        ;roll contents of al by 4
bits
        mov dl,al                       ;copy al into dl
        and dl,0FH                      ;AND dl with 0Fh
        cmp dl,09h                      ;compare dl with 09h
        jbe next2                       ;jump to next2, if dl is
below or equal
        add dl,07h                      ;add 07h to dl
next2:  add dl,30h                      ;add 30h to dl
        mov[esi],dl                     ;move dl at esi address
        inc esi                         ;increment esi
        dec ecx                         ;decrement ecx
        jnz up4                         ;jump to up4, if ecx not
zero

        scall 4,1,m3,l3                 ;macro call to display m3
        scall 4,1,char_ans,2            ;macro call to display
char_ans
        scall 4,1,m4,l4                 ;macro call to display m4

        mov eax,1                       ;sys_Exit
        mov ebx,0                       ;sucessfull termination
        int 80h                         ;call the kernel


asciihextohex:                          ;procedure
mov ecx,2                               ;copy 2 into ecx
mov dl,0                                ;copy 0 into dl

top:    rol dl,4                        ;roll contents of dl by 4
bits
        mov al,[esi]                    ;copy esi contents into al
        cmp al,39h                      ;compare al with 39h
        jbe down                        ;jump to down, if al is
below or equal
        sub al,07h                      ;subtract 07h
down:   sub al,30h                      ;subtract 30h
        add dl,al                       ;add al with dl
        inc esi                         ;increment esi
```

```
        loop top                                    ;jump if ecx not equal to
zero,decrement ecx
ret                                                 ;return to calling address
```

32 Bit NASM Code for Double Word

```
%macro scall 4                                  ;macro declaration with 4
parameters
        mov eax,%1                              ;1st parameter has been moved to
eax
        mov ebx,%2                              ;2nd parameter has been moved to
ebx
        mov ecx,%3                              ;3rd parameter has been moved to
ecx
        mov edx,%4                              ;4th parameter has been moved to
edx
        int 80h                                 ;Call the Kernel
%endmacro                                       ;end of macro

section .data                                       ;.data segment begins here
        m1 db "Enter size of array: ",10d,13d       ;m1 initialised with a
string
        l1 equ $-m1                                 ;l1 stores length of m1
string
        m2 db "Enter array elements: ",10d,13d      ;m2 initialised with a
string
        l2 equ $-m2                                 ;l2 stores length of m2
string
        m3 db 10d,13d,"Largest: "                   ;m3 initialised with a
string
        l3 equ $-m3                                 ;l3 stores length of m3
string
        m4 db 10d,13d                               ;m4 initialised with a
string
        l4 equ $-m4                                 ;l4 stores length of m4
string
        m5 db "Array Elements are: ",10d,13d
        l5 equ $-m5
section .bss

        cnt resb 3
        arr resb 9
        cnt1 resb 3
        cnt2 resb 2
        arr1 resb 50
        temp resd 1
        char_ans resb 8


section .text
```

```
        global _start

_start:

;accept count

        scall 4,1,m1,l1
        scall 3,0,arr,3

        mov esi,arr
        mov ecx,2
        mov dl,0
   up:
        rol dl,4
        mov al,[esi]
        cmp al,39h
        jbe L1
        sub al,07h
  L1:
        sub al,30h
        add dl,al
        inc esi
        loop up

        mov byte[cnt],dl
        mov byte[cnt1],dl
        mov byte[cnt2],dl

;accept array

        scall 4,1,m2,l2
        mov edi,arr1
back:
        scall 3,0,arr,9

        mov esi,arr

        mov ecx,8
        mov edx,0
        mov eax,0
   up1:
        rol edx,4
        mov al,[esi]
        cmp al,39h
        jbe L2
        sub al,07h
  L2:
        sub al,30h
        add edx,eax
        inc esi
        dec ecx
        jnz up1
        mov [edi],edx
```

```
        add edi,9
        dec byte[cnt]
        jnz back
;Displaying array elements
        scall 4,1,m5,l5
        mov edi,arr1
up4:
        mov ecx,08
        mov esi,char_ans
        mov eax,[edi]
  up6:
        rol eax,4
        mov dl,al
        and dl,0fh
        cmp dl,09h
        jbe nxt1
        add dl,07h
 nxt1:
        add dl,30h
        mov [esi],dl
        inc esi
        dec ecx
        jnz up6
        scall 4,1,char_ans,8
        scall 4,1,m4,l4
        add edi,9
        dec byte[cnt2]
        jnz up4


;Finding Largest Number
        mov esi,arr1
        mov eax,[esi]
        add esi,9
  up2:
        mov ebx,[esi]
        cmp eax,ebx
        jg next
        mov [temp],eax
        mov eax,ebx
        mov ebx,[temp]

    next:
        add esi,9
        dec byte[cnt1]
        jnz up2

;Displaying Largest Number

        mov ecx,08
        mov esi,char_ans
   up3:
        rol eax,4
```

```
        mov dl,al
        and dl,0fh
        cmp dl,09h
        jbe nxt
        add dl,07h
  nxt:
        add dl,30h
        mov [esi],dl
        inc esi
        dec ecx
        jnz up3

        scall 4,1,m3,l3
        scall 4,1,char_ans,8
        scall 4,1,m4,l4


        mov eax,1
        mov ebx,0
        int 80h
```

64 Bit NASM Code for Quad Word

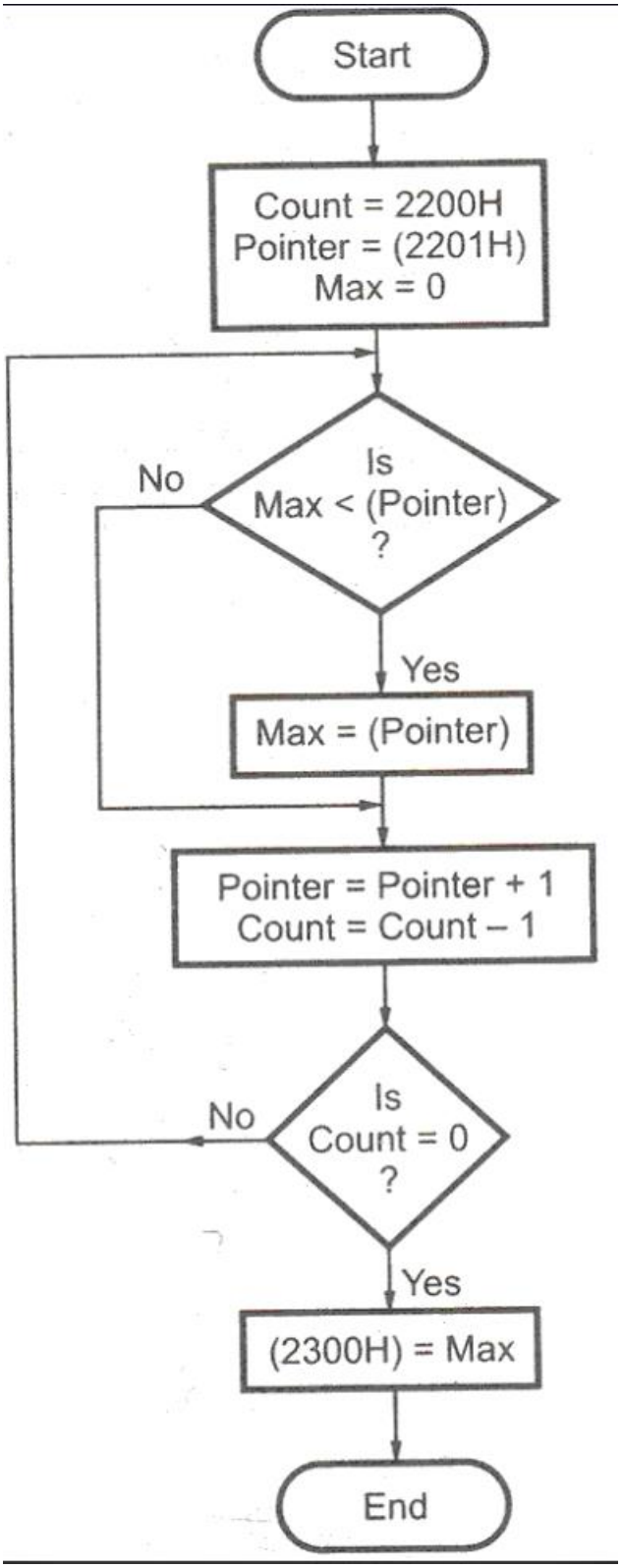
```
%macro scall 4
        mov rax,%1
        mov rdi,%2
        mov rsi,%3
        mov rdx,%4
        syscall
%endmacro

section .data

        m1 db "Enter Count of numbers: ",10
        l1 equ $-m1
        m2 db "Enter the numbers: ",10
        l2 equ $-m2
        m3 db "Largest Number is: ",10
        l3 equ $-m3
        m4 db " ",10
        l4 equ $-m4
        m5 db "Array Elements are: ",10
        l5 equ $-m5
section .bss

        cnt resb 3
        arr resb 17
        cnt1 resb 3
        cnt2 resb 3
        arr1 resb 100
        temp resq 1
```

```
        char_ans resb 16


section .text

        global _start

_start:

;accept count

        scall 1,1,m1,l1
        scall 0,0,arr,3

        mov rsi,arr
        mov rcx,2
        mov rdx,0
   up:
        rol dl,4
        mov al,[rsi]
        cmp al,39h
        jbe L1
        sub al,07h
  L1:
        sub al,30h
        add dl,al
        inc rsi
        loop up

        mov byte[cnt],dl
        mov byte[cnt1],dl
        mov byte[cnt2],dl

;accept array

        scall 1,1,m2,l2
        mov rbx,arr1
back:
        scall 0,0,arr,17

        mov rsi,arr

        mov rcx,16
        mov rdx,0
        mov rax,0
   up1:
        rol rdx,4

        mov al,[rsi]

        cmp al,39h
        jbe L2
        sub al,07h
```

```
  L2:
        sub al,30h

        add rdx,rax

        inc rsi

        dec rcx
        jnz up1

        mov [rbx],rdx

        add rbx,17
        dec byte[cnt]
        jnz back


;***********Displaying array elements*******************
        scall 1,1,m5,l5
        mov rbx,arr1
up4:
        mov rcx,16
        mov rsi,char_ans
        mov rax,[rbx]
  up6:
        rol rax,4
        mov dl,al
        and dl,0Fh

        cmp dl,09h
        jbe nxt1
        add dl,07h
nxt1:
        add dl,30h

        mov [rsi],dl

        inc rsi
        dec rcx
        jnz up6

        scall 1,1,char_ans,16
        scall 1,1,m4,l4

        add rbx,17
        dec byte[cnt2]
        jnz up4

;******************Finding Largest Number**********************************
        mov rsi,arr1
        mov rax,[rsi]
        add rsi,17
  up2:
```

```
        mov rbx,[rsi]
        cmp rax,rbx
        jg next
        mov [temp],rax
        mov rax,rbx
        mov rbx,[temp]

    next:
        add rsi,17
        dec byte[cnt1]
        jnz up2

;**************************Displaying Largest
Number*****************************

        mov rcx,16
        mov rsi,char_ans
   up3:
        rol rax,4
        mov dl,al
        and dl,0fh
        cmp dl,09h
        jbe nxt
        add dl,07h
  nxt:
        add dl,30h
        mov [rsi],dl
        inc rsi
        dec rcx
        jnz up3

        scall 1,1,m3,l3
        scall 1,1,char_ans,16
        scall 1,1,m4,l4



        mov rax,60
        mov rbx,0
        syscall
```

FLOWCHART:



CONCLUSION: In this practical session we learnt to find the largest of given Byte / Word / Dword / 64-Bit Numbers.

EXPERIMENT NO. 06

NAME: Write X86/64 ALP to detect protected mode and display the values of GDTR, LDTR, IDTR, TR and MSW Registers also identify CPU type using CPUID instruction.

AIM: Write X86/64 ALP to detect protected mode and display the values of GDTR, LDTR, IDTR, TR and MSW Registers also identify CPU type using CPUID instruction.

OBJECTIVES:

- To understand assembly language programming instruction set.
- To understand different assembler directives with example.
- To apply instruction set for implementing X86/64 bit assembly language programs

ENVIRONMENT:

- Operating System: 64-bit Open source Linux or its derivative.
- Programming Tools: Preferably using Linux equivalent or MASM/TASM/NASM/FASM.
- Text Editor: geditor

THEORY:

Real Mode:

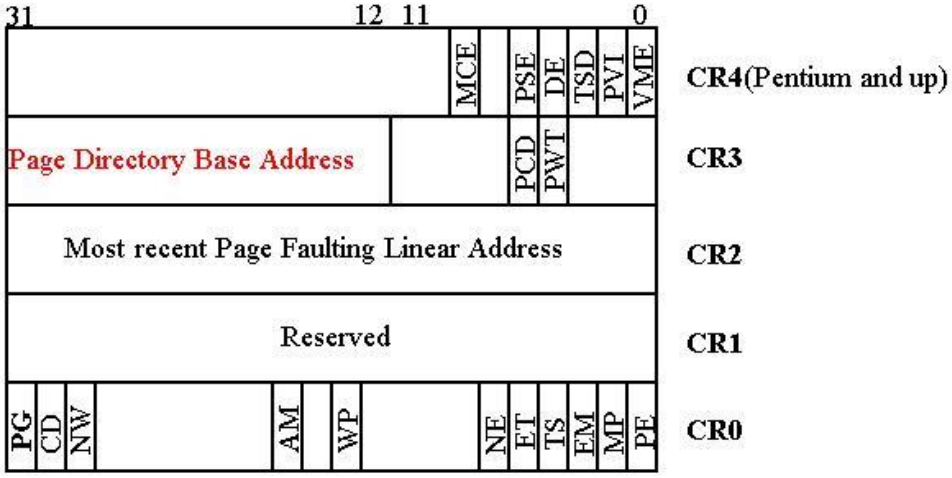
Real mode, also called real address mode, is an operating mode of all x86-compatible CPUs. Real mode is characterized by a 20-bit segmented memory address space (giving exactly 1 MiB of addressable memory) and unlimited direct software access to all addressable memory, I/O addresses and peripheral hardware. Real mode provides no support for memory protection, multitasking, or code privilege levels.

Protected Mode:

In computing, protected mode, also called protected virtual address mode is an operational mode of x86-compatible central processing units (CPUs). It allows system software to use features such as virtual memory, paging and safe multi-tasking designed to increase an operating system's control over application software.

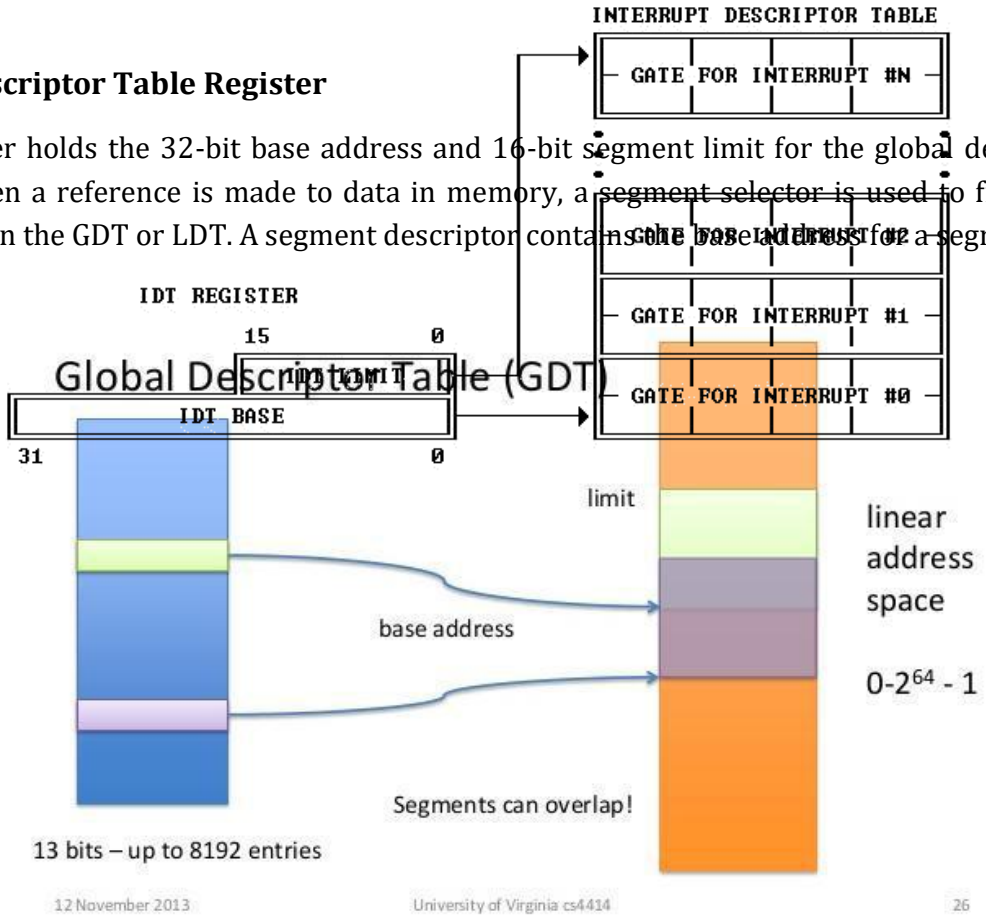
When a processor that supports x86 protected mode is powered on, it begins executing instructions in real mode, in order to maintain backward compatibility with earlier x86 processors. Protected mode may only be entered after the system software sets up several descriptor tables and enables the Protection Enable (PE) bit in the control register 0 (CR0).

Control Register :



Global Descriptor Table Register

This register holds the 32-bit base address and 16-bit segment limit for the global descriptor table (GDT). When a reference is made to data in memory, a segment selector is used to find a segment descriptor in the GDT or LDT. A segment descriptor contains the base address for a segment.



Local Descriptor Table Register

This register holds the 32-bit base address, 16-bit segment limit, and 16-bit segment selector for the local descriptor table (LDT). The segment which contains the LDT has a segment descriptor in the GDT. There is no segment descriptor for the GDT. When a reference is made to data in memory, a segment selector is used to find a segment descriptor in the GDT or LDT. A segment descriptor contains the base address for a segment

Interrupt Descriptor Table Register

This register holds the 32-bit base address and 16-bit segment limit for the interrupt descriptor table (IDT). When an interrupt occurs, the interrupt vector is used as an index to get a gate descriptor from this table. The gate descriptor contains a far pointer used to start up the interrupt handler.

ALGORITHM:

- Start
- Display the message using sys_write call
- Read CR0
- Checking PE bit, if 1=Protected Mode
- Load number of digits to display
- Rotate number left by four bits
- Convert the number in ASCII
- Display the number from buffer
- Exit using sys_exit call

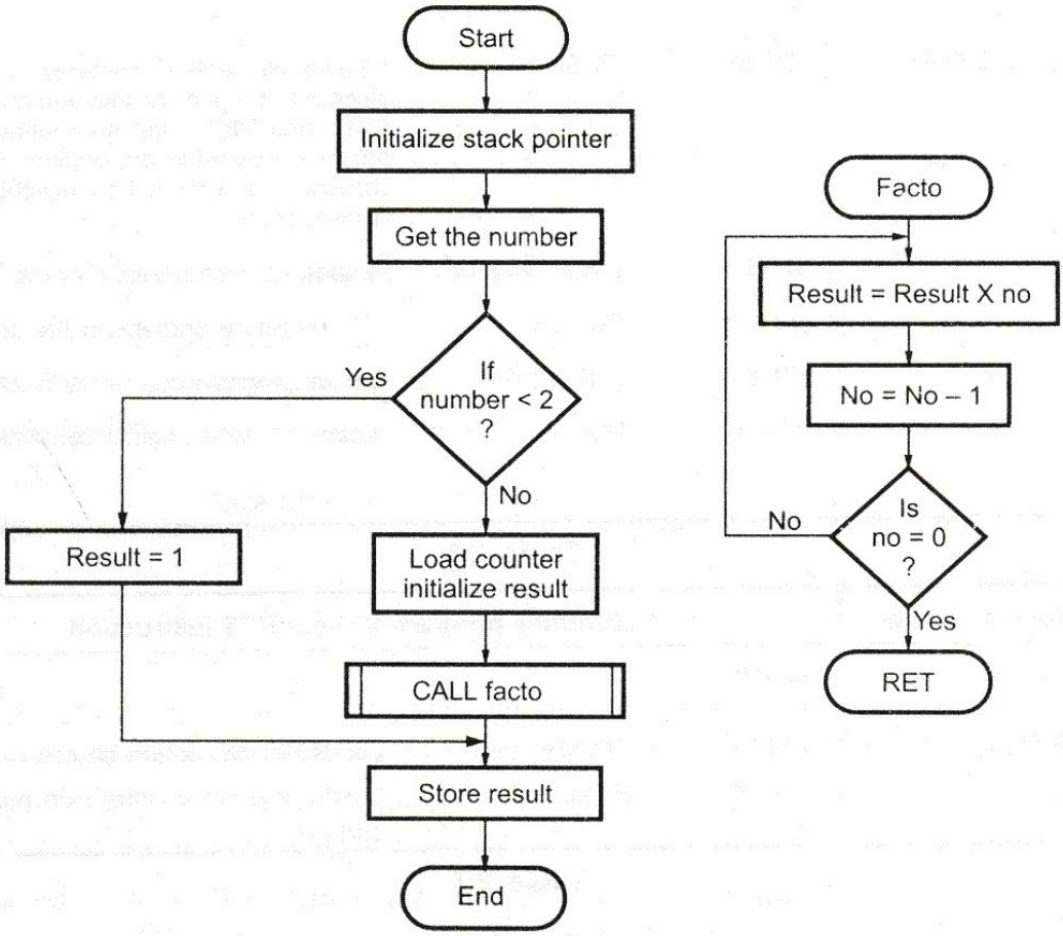
PROGRAM:

```
section .data
 rmodemsg db 10,'Processor is in Real Mode'
 rmsg_len:equ $-rmodemsg

 pmodemsg db 10,'Processor is in Protected Mode'
 pmsg_len:equ $-pmodemsg

 gdtmsg db 10,'GDT Contents are::'
 gmsg_len:equ $-gdtmsg

 ldtmsg db 10,'LDT Contents are::'
 lmsg_len:equ $-ldtmsg

 idtmsg db 10,'IDT Contents are::'
 imsg_len:equ $-idtmsg

 trmsg db 10,'Task Register Contents are::'
 tmsg_len: equ $-trmsg

 mswmsg db 10,'Machine Status Word::'
 mmsg_len:equ $-mswmsg

 colmsg db ':'

 nwline db 10

section .bss
 gdt resd 1
    resw 1
 ldt resw 1
 idt resd 1
```

```
    resw 1
 tr  resw 1

 cr0_data resd 1

 dnum_buff resb 04

%macro print 2
 mov rax,01
 mov rdi,01
 mov rsi,%1
 mov rdx,%2
 syscall
%endmacro

section .text
global _start
_start:
 smsw eax  ;Reading CR0. As MSW is 32-bit cannot use RAX register.

 mov [cr0_data],rax

 bt rax,1  ;Checking PE bit, if 1=Protected Mode, else Real Mode
 jc prmode
 print rmodemsg,rmsg_len
 jmp nxt1

prmode: print pmodemsg,pmsg_len

nxt1: sgdt [gdt]
 sldt [ldt]
 sidt [idt]
 str [tr]
 print gdtmsg,gmsg_len

 mov bx,[gdt+4]
 call print_num

 mov bx,[gdt+2]
 call print_num

 print colmsg,1

 mov bx,[gdt]
 call print_num

 print ldtmsg,lmsg_len
 mov bx,[ldt]
 call print_num

 print idtmsg,imsg_len

 mov bx,[idt+4]
 call print_num
```

```
 mov bx,[idt+2]
 call print_num

 print colmsg,1

 mov bx,[idt]
 call print_num

 print trmsg,tmsg_len

 mov bx,[tr]
 call print_num

 print mswmsg,mmsg_len

 mov bx,[cr0_data+2]
 call print_num

 mov bx,[cr0_data]
 call print_num

 print nwline,1

exit: mov rax,60
 xor rdi,rdi
 syscall

print_num:
 mov rsi,dnum_buff ;point esi to buffer

 mov rcx,04  ;load number of digits to printlay

up1:
 rol bx,4  ;rotate number left by four bits
 mov dl,bl  ;move lower byte in dl
 and dl,0fh  ;mask upper digit of byte in dl
 add dl,30h  ;add 30h to calculate ASCII code
 cmp dl,39h  ;compare with 39h
 jbe skip1  ;if less than 39h skip adding 07 more
 add dl,07h  ;else add 07
skip1:
 mov [rsi],dl  ;store ASCII code in buffer
 inc rsi   ;point to next byte
 loop up1  ;decrement the count of digits to printlay
    ;if not zero jump to repeat

 print dnum_buff,4 ;printlay the number from buffer
 ret
```

FLOWCHART:



CONCLUSION:

In this practical session we learnt to detect protected mode and display the values of GDTR, LDTR, IDTR, TR and MSW Registers also identified CPU type using CPUID instruction.

EXPERIMENT NO. 07

NAME: Write X86/64 ALP to perform non-overlapped block transfer without string specific instructions. Block containing data can be defined in the data segment.

AIM: Write X86/64 ALP to perform non-overlapped block transfer without string specific instructions. Block containing data can be defined in the data segment.

OBJECTIVES:

- To understand assembly language programming instruction set.
- To understand different assembler directives with example.
- To apply instruction set for implementing X86/64 bit assembly language programs

ENVIRONMENT:

- Operating System: 64-bit Open source Linux or its derivative.
- Programming Tools: Preferably using Linux equivalent or MASM/TASM/NASM/FASM.
- Text Editor: geditor

THEORY:

- Consider that a block of data of N bytes is present at source location. Now this block of N bytes is to be moved from source location to a destination location.
- Let the number of bytes N = 05.
- We will have to initialize this as count.
- We know that source address is in the ESI register and destination address is in the EDI register.
- For block transfer without string instruction, move contents at ESI to accumulator and from accumulator to memory location of EDI and increment ESI and EDI for next content transfer.

- For block transfer with string instruction, clear the direction flag. Move the data from source location to the destination location using string instruction.

Instructions needed:

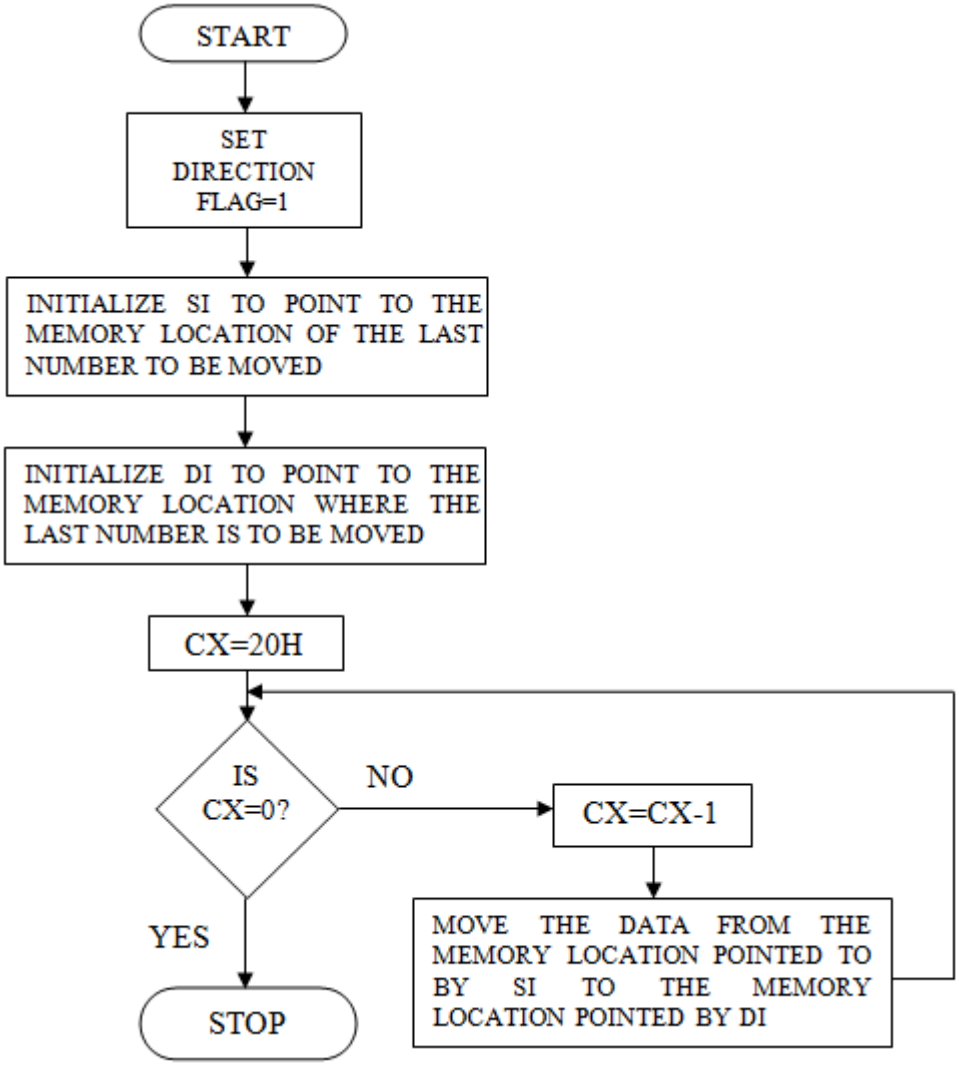
1. **MOVSB**-This is a string instruction and it moves string byte from source to destination.
2. **REP-** This is prefix that are applied to string operation. Each prefix cause the string instruction that follows to be repeated the number of times indicated in the count register.
3. **CLD-** Clear Direction flag. ESI and EDI will be incremented and DF = 0
4. **STD-** Set Direction flag. ESI and EDI will be incremented and DF = 1
5. **ROL**-Rotates bits of byte or word left.

6. **AND**-AND each bit in a byte or word with corresponding bit in another byte or word.
7. **INC**-Increments specified byte/word by1.
8. **DEC**-Decrements specified byte/word by1.
9. **JNZ**-Jumps if not equal to Zero.
10. **JNC**-Jumps if no carry is generated.
11. **CMP-**Compares to specified bytes or words.
12. **JBE**-Jumps if below or equal.
13. **ADD**-Adds specified byte to byte or word to word.
14. **CALL**-Transfers the control from calling program to procedure.
15. **RET**-Return from where call is made.

ALGORITHM:

1. Initialize ESI and EDI with source and destination address.
2. Move count in ECX register.
3. Move contents at ESI to accumulator and from accumulator to memory location of EDI.
4. Increment ESI and EDI to transfer next content.
5. Repeat procedure till count becomes zero.

FLOWCHART:



PROGRAM:

```
section .data

array db 10h,20h,30h,40h,50h


      msg1: db 'Before overlapped :',0xa
len1: equ $-msg1
```

```
msg2: db 'After overlapped :',0xa
len2: equ $-msg2

      msg3: db ' ',0xa
len3: equ $-msg3

      msg4: db ' : '
len4: equ $-msg4


      count db 0
      count1 db 0
      count2 db 0
      count3 db 0
      count4  db 0



section .bss
 addr resb 16
       num1 resb 2


section .text
global _start


_start:


      mov rax,1
mov rdi,1
mov rsi,msg1
mov rdx,len1
syscall

      xor rsi,rsi

mov rsi,array
mov byte[count],05

up:
      mov rbx,rsi
push rsi
      mov rdi,addr
```

```
call HtoA1
pop rsi


mov dl,[rsi]
push rsi
      mov rdi,num1
call HtoA2
pop rsi

inc rsi

dec byte[count]
jnz up


      mov rsi,array
      mov rdi,array+5h
mov byte[count3],05h

     loop10:
      mov dl,00h
      mov dl,byte[rsi]
      mov byte[rdi],dl
      inc rsi
      inc rdi
      dec byte[count3]
      jnz loop10


      mov rax,1
mov rdi,1
mov rsi,msg2
mov rdx,len2
syscall

      mov rsi,array
      mov byte[count4],0Ah



      up10:
      mov rbx,rsi
push rsi
      mov rdi,addr
call HtoA1
```

```
pop rsi

mov dl,[rsi]
push rsi
      mov rdi,num1
call HtoA2
pop rsi

inc rsi

dec byte[count4]
jnz up10


      mov rax,60
mov rdi,0
syscall

HtoA1:
mov byte[count1],16

dup1:
rol rbx,4
mov al,bl
and al,0fh
cmp al,09
jg p3
add al,30h
jmp p4
p3: add al,37h
p4:mov [rdi],al
inc rdi
      dec byte[count1]
      jnz dup1



      mov rax,1
mov rdi,1
mov rsi,addr
mov rdx,16
syscall

      mov rax,1
mov rdi,1
mov rsi,msg4
mov rdx,len4
```

```
 syscall

ret

HtoA2:
 mov byte[count2],02

 dup2:

 rol dl,04
 mov al,dl
 and al,0fh
 cmp al,09h
 jg p31
 add al,30h
 jmp p41

 p31: add al,37h
 p41:mov [rdi],al

 inc rdi
 dec byte[count2]
       jnz dup2

       mov rax,1
 mov rdi,1
 mov rsi,num1
 mov rdx,02
 syscall

       mov rax,1
 mov rdi,1
 mov rsi,msg3
 mov rdx,len3
 syscall
ret



OUTPUT:
; nasm -f elf64 nonover_string.asm
;ld -o nonover_string nonover_string.o
;./nonover_string


;Before overlapped :
;0000000000600270 : 10
```

;0000000000600271 : 20
;0000000000600272 : 30
;0000000000600273 : 40
;0000000000600274 : 50

;After overlapped :
;0000000000600270 : 10
;0000000000600271 : 20
;0000000000600272 : 30
;0000000000600273 : 40
;0000000000600274 : 50
;0000000000600275 : 10
;0000000000600276 : 20
;0000000000600277 : 30
;0000000000600278 : 40
;0000000000600279 : 50

CONCLUSION:

In this practical session we learnt how to perform non-overlapped block transfer without string specific

instructions.

EXPERIMENT NO. 08

NAME: Write X86/64 ALP to perform overlapped block transfer with string specific instructions

Block containing data can be defined in the data segment.

AIM: Write X86/64 ALP to perform overlapped block transfer with string specific instructions

Block containing data can be defined in the data segment.

OBJECTIVES:

- To understand assembly language programming instruction set.
- To understand different assembler directives with example.
- To apply instruction set for implementing X86/64 bit assembly language programs

ENVIRONMENT:

- Operating System: 64-bit Open source Linux or its derivative.
- Programming Tools: Preferably using Linux equivalent or MASM/TASM/NASM/FASM.
- Text Editor: geditor

THEORY:

- Consider that a block of data of N bytes is present at source location. Now this block of N bytes is to be moved from source location to a destination location.
- Let the number of bytes N = 05.
- We will have to initialize this as count.
- Overlap the source block and destination block.

- We know that source address is in the ESI register and destination address is in the EDI register.
- For block transfer without string instruction, move contents at ESI to accumulator and from accumulator to memory location of EDI and decrement ESI and EDI for next content transfer.
- For block transfer with string instruction, set the direction flag. Move the data from source location to the destination location using string instruction.

Instructions needed:

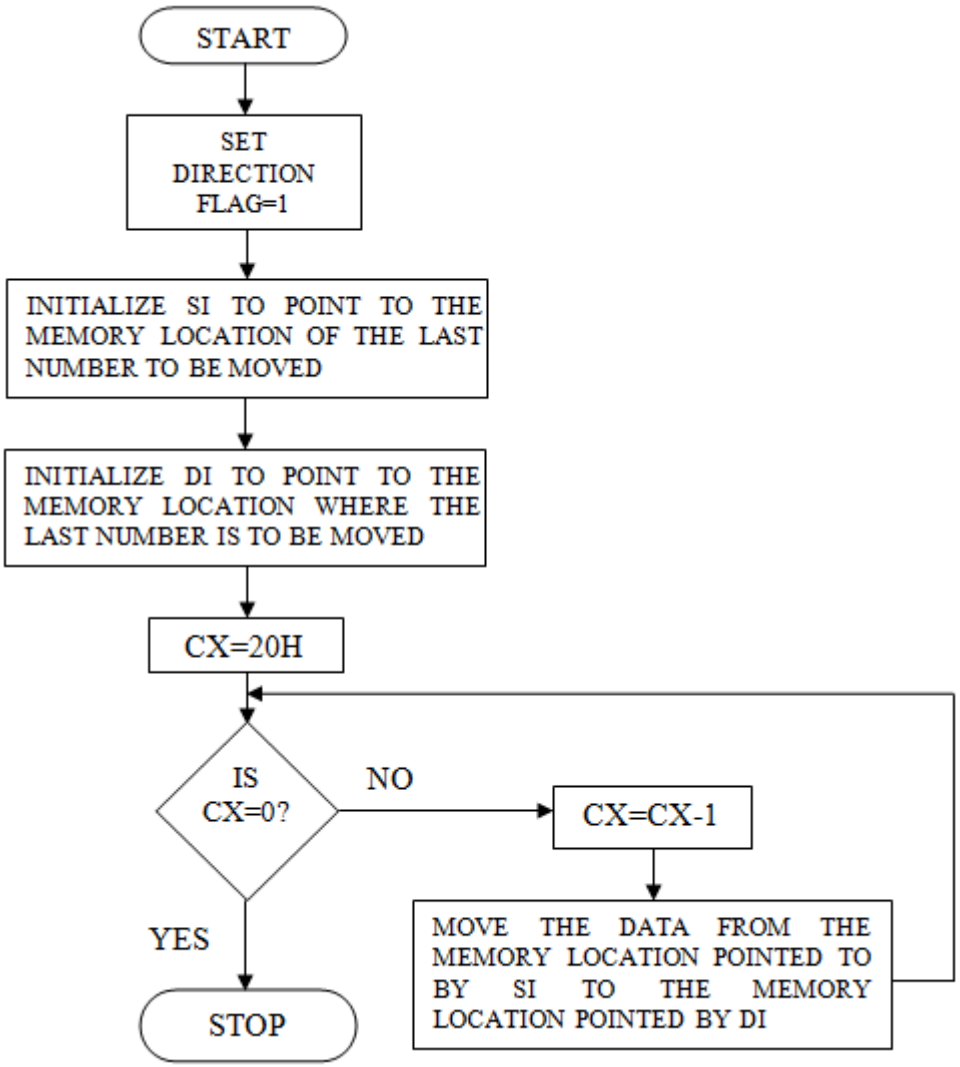
1. **MOVSB**-This is a string instruction and it moves string byte from source to destination.
2. **REP-** This is prefix that are applied to string operation. Each prefix cause the string instruction that follows to be repeated the number of times indicated in the count register.
3. **CLD-** Clear Direction flag. ESI and EDI will be incremented and DF = 0
4. **STD-** Set Direction flag. ESI and EDI will be decremented and DF = 1
5. **ROL**-Rotates bits of byte or word left.
6. **AND**-AND each bit in a byte or word with corresponding bit in another byte or word.
7. **INC**-Increments specified byte/word by1.
8. **DEC**-Decrements specified byte/word by1.
9. **JNZ-**Jumps if not equal to Zero.
10. **JNC**-Jumps if no carry is generated.
11. **CMP**-Compares to specified bytes or words.
12. **JBE**-Jumps if below or equal.

13. **ADD**-Adds specified byte to byte or word to word.
14. **CALL**-Transfers the control from calling program to procedure.
15. **RET**-Return from where call is made.

ALGORITHM:

1. Initialize ESI and EDI with source and destination address.
2. Move count in ECX register.
3. Move source block's and destination block's last content address in ESI and EDI.
4. Move contents at ESI to accumulator and from accumulator to memory location of EDI.
5. Decrement ESI and EDI to transfer next content.
6. Repeat procedure till count becomes zero.

FLOWCHART:


START
SET DIRECTION FLAG=1
INITIALIZE SI TO POINT TO THE MEMORY LOCATION OF THE LAST NUMBER TO BE MOVED
INITIALIZE DI TO POINT TO THE MEMORY LOCATION WHERE THE LAST NUMBER IS TO BE MOVED
CX=20H
IS CX=0?
NO
CX=CX-1
MOVE THE DATA FROM THE MEMORY LOCATION POINTED TO BY SI TO THE MEMORY LOCATION POINTED BY DI
YES
STOP

PROGRAM:

```
section .data

array db 10h,20h,30h,40h,50h


      msg1: db 'Before overlapped :',0xa
len1: equ $-msg1

msg2: db 'After overlapped :',0xa
len2: equ $-msg2

      msg3: db ' ',0xa
len3: equ $-msg3

      msg4: db ' : '
len4: equ $-msg4


      count db 0
      count1 db 0
      count2 db 0
      count3 db 0
      count4  db 0
      count5  db 0



section .bss
 addr resb 16
       num1 resb 2


section .text
global _start


_start:


      mov rax,1
mov rdi,1
mov rsi,msg1
mov rdx,len1
syscall
```

```
        xor rsi,rsi

mov rsi,array
mov byte[count],05

up:
        mov rbx,rsi
push rsi
        mov rdi,addr
call HtoA1
pop rsi


mov dl,[rsi]
push rsi
        mov rdi,num1
call HtoA2
pop rsi

inc rsi

dec byte[count]
jnz up


        mov rsi,array
        mov rdi,array+0Ah
mov byte[count3],05h

       loop10:
        mov dl,00h
        mov dl,byte[rsi]
        mov byte[rdi],dl
        inc rsi
        inc rdi
        dec byte[count3]
        jnz loop10

        xor rsi,rsi

        mov rsi,array+3h
        mov rdi,array+0Ah
mov byte[count5],05h

        loop11:
```

```
        mov dl,byte[rdi]
        mov byte[rsi],dl
        inc rsi
        inc rdi
        dec byte[count5]
        jnz loop11



        mov rax,1
 mov rdi,1
 mov rsi,msg2
 mov rdx,len2
 syscall

        xor rsi,rsi
        mov rsi,array
        mov byte[count4],08h

        up10:
        mov rbx,rsi
 push rsi
        mov rdi,addr
 call HtoA1
 pop rsi

 mov dl,[rsi]
 push rsi
        mov rdi,num1
 call HtoA2
 pop rsi

 inc rsi

 dec byte[count4]
 jnz up10


        mov rax,60
 mov rdi,0
 syscall

HtoA1:
 mov byte[count1],16
```

```
dup1:
rol rbx,4
mov al,bl
and al,0fh
cmp al,09
jg p3
add al,30h
jmp p4
p3: add al,37h
p4:mov [rdi],al
inc rdi
      dec byte[count1]
      jnz dup1


      mov rax,1
mov rdi,1
mov rsi,addr
mov rdx,16
syscall


      mov rax,1
mov rdi,1
mov rsi,msg4
mov rdx,len4
syscall


ret

HtoA2:
mov byte[count2],02

dup2:

rol dl,04
mov al,dl
and al,0fh
cmp al,09h
jg p31
add al,30h
jmp p41

p31: add al,37h
p41:mov [rdi],al
```

```
inc rdi
dec byte[count2]
      jnz dup2

      mov rax,1
mov rdi,1
mov rsi,num1
mov rdx,02
syscall

      mov rax,1
mov rdi,1
mov rsi,msg3
mov rdx,len3
syscall


ret
```

OUTPUT:

```
;nasm -f elf64 with_over.asm
; ld -o with_over with_over.o
;./with_over
;Before overlapped :
;00000000006002A4 : 10
;00000000006002A5 : 20
;00000000006002A6 : 30
;00000000006002A7 : 40
;00000000006002A8 : 50
;After overlapped :
;00000000006002A4 : 10
;00000000006002A5 : 20
;00000000006002A6 : 30
;00000000006002A7 : 10
;00000000006002A8 : 20
;00000000006002A9 : 30
;00000000006002AA : 40
;00000000006002AB : 50
```

CONCLUSION: In this practical session we learnt how to perform non-overlapped block transfer with string specific instructions.

EXPERIMENT NO. 09

NAME: Write X86/64 ALP to perform multiplication of two 8-bit hexadecimal numbers. Use successive addition and add and shift method. (use of 64-bit registers is expected).

AIM: Write X86/64 ALP to perform multiplication of two 8-bit hexadecimal numbers. Use successive addition and add and shift method. (use of 64-bit registers is expected).

OBJECTIVES:

- To understand assembly language programming instruction set.
- To understand different assembler directives with example.
- To apply instruction set for implementing X86/64 bit assembly language programs

ENVIRONMENT:

- Operating System: 64-bit Open source Linux or its derivative.
- Programming Tools: Preferably using Linux equivalent or MASM/TASM/NASM/FASM.
- Text Editor: geditor

THEORY:

A) Multiplication of two numbers using successive addition method:

Historically, computers used a "shift and add" algorithm for multiplying small integers. Both base 2 long multiplication and base 2 peasant multiplications reduce to this same algorithm. In base 2, multiplying by the single digit of the multiplier reduces to a simple series of logical AND operations. Each partial product is added

to a running sum as soon as each partial product is computed. Most currently available microprocessors implement this or other similar algorithms (such as Booth encoding) for various integer and floating-point sizes in hardware multipliers or in microcode.

On currently available processors, a bit-wise shift instruction is faster than a multiply instruction and can be used to multiply (shift left) and divide (shift right) by powers of two. Multiplication by a constant and division by a constant can be implemented using a sequence of shifts and adds or subtracts. For example, there are several ways to multiply by 10 using only bit-shift and addition.

```
((x << 2) + x) << 1 # Here 10*x is computed as (x*2^2 + x)*2
(X << 3) + (x << 1) # Here 10*x is computed as x*2^3 + x*2
```

In some cases such sequences of shifts and adds or subtracts will outperform hardware multipliers and especially dividers. A division by a number of the form 2^n or $2^n \pm 1$ often can be converted to such a short sequence. These types of sequences have to always be used for computers that do not have a "multiply" instruction,[4] and can also be used by extension to floating point numbers if one replaces the shifts with computation of *2*x* as *x+x*, as these are logically equivalent.

Example:

Consider that a byte is present in the AL register and second byte is present in the BL register.

Step 1: We have to multiply the byte in AL with the byte in BL.

Step 2: We will multiply the numbers using successive addition method.

Step 3: In successive addition method, one number is accepted and other number is taken as a counter. The first number is added with itself, till the counter decrements to zero.

Step 4: Result is stored in DX register. Display the result, using display routine.

For example: AL = 12 H, BL = 10 H

Solution:

Result = 12H + 12H + 12H + 12H + 12H + 12H + 12H + 12H + 12H+ 12H

Result = 0120 H

Algorithm to Multiply Two 8 Bit Numbers Successive Addition Method:

Step I : Initialize the data segment.

Step II : Get the first number.

Step III : Get the second number as counter.

Step IV : Initialize result = 0.

Step V : Result = Result + First number.

Step VI : Decrement counter

Step VII : If count ¹ 0, go to step V.

Step VIII : Display the result.

Step IX : Stop.

B) Multiply Two 8 Bit Numbers using Add and Shift Method:

Program should take first and second numbers as input to the program. Now it should implement certain logic to multiply 8 bit Numbers using Add and Shift Method. Consider that one byte is present in the AL register and another byte is present in the BL register. We have to multiply the byte in AL with the byte in BL.

Steps for multiply the numbers using add and shift method:

Step 1: In this method, you add number with itself

Step 2: Rotate the other number each time and shift it by one bit to left along with carry. If carry is present add the two numbers.

Step 3: Initialize the count to 4 as we are scanning for 4 digits. Decrement counter each time the bits are added. The result is stored in AX. Display the result.

For example: AL = 11 H, BL = 10 H, Count = 4

Solution:

Step I : AX= 11

\+ **11**
22H

Rotate BL by one bit to left along with carry

BL=10 H 0 0001 0000

CY 10

After Rotate BL by one bit to left along with carry

BL= 0 0010 0000

CY 20

Step II : Now decrement counter count = 3.

Check for carry, carry is not there so add number with itself.

AX=22

\+ **22**

~~44H~~

Rotate BL to left,

BL= 0 0010 0000

CY 20

After Rotate BL by one bit to left along with carry

BL= 0 0100 0000

CY 40

Carry is not there.

Decrement count, count=2

Step III : Add number with itself

AX=44

\+ **44**
88H

Rotate BL to left,

BL= 0 0100 0000

CY 40

After Rotate BL by one bit to left along with carry

BL= 0 1000 0000

CY 80

Carry is not there.

Step IV : Decrement counter count = 1.

Add number with itself as carry is not there.

AX=88

\+ **88**

110H

Rotate BL to left,

BL= 0 1000 0000

CY 80

After Rotate BL by one bit to left along with carry

BL= 1 0000 0000

CY 00

Carry is there.

Step V : Decrement counter = 0.

Carry is present.

\ add AX, BX

0110 i.e.11 H

\+ 0000 i.e.10 H

0110 H 0110H

Algorithm to Multiply Two 8 Bit Numbers using Add and Shift Method:

Step I : Get the first number.

Step II : Get the second number

Step III : Initialize count = 04.

Step IV : number 1 = number 1 ´ 2.

Step V : Shift multiplier to left along with carry.

Step VI : Check for carry, if present go to step VIII else go to step IX.

Step VII : number 1 = number1 + shifted number 2.

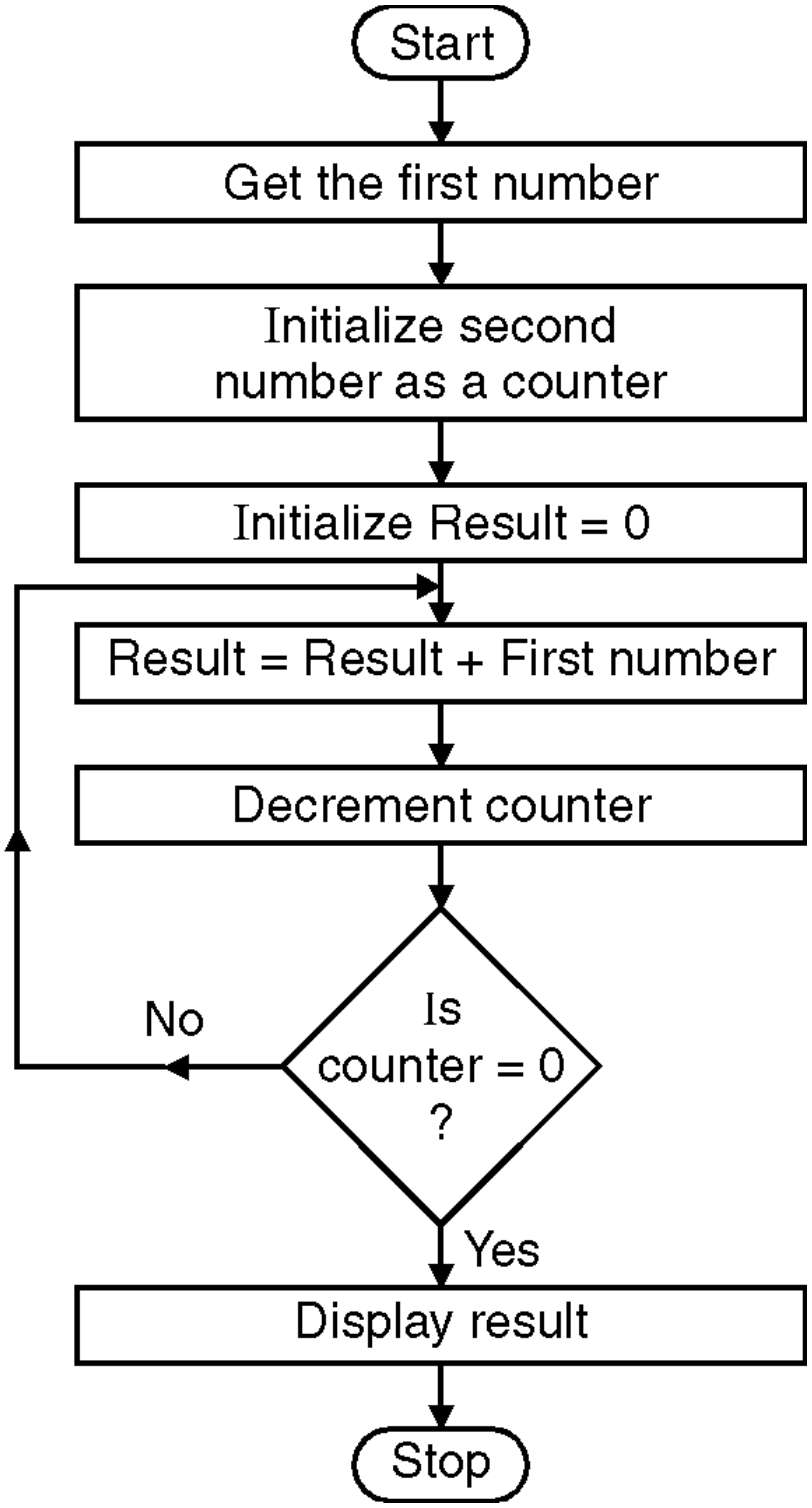
Step VIII : Decrement counter.

Step IX : If not zero, go to step V.

Step X : Display the result.

Step XI : Stop.

FLOWCHART:


Start
Get the first number
Initialize second number as a counter
Initialize Result = 0
Result = Result + First number
Decrement counter
Is counter = 0 ?
No
Yes
Display result
Stop

PROGRAM:

```
section .data

msg db 'Enter two digit Number::',0xa
msg_len equ $-msg
res db 10,'Multiplication of elements is::'
res_len equ $-res
choice db 'Enter your Choice:',0xa
      db'1.Successive Addition',0xa
      db '2.Add and Shift method',0xa
      db '3.Exit',0xa
choice_len equ $-choice

section .bss
num resb 03
num1 resb 01
result resb 04
cho resb 2


section .text

global _start
_start:

 xor rax,rax
 xor rbx,rbx
 xor rcx,rcx
 xor rdx,rdx
 mov byte[result],0
 mov byte[num],0
 mov byte[num1],0

       mov rax,1
 mov rdi,1
 mov rsi,choice
 mov rdx,choice_len
 syscall



       mov rax,0                ;; read choice
```

```
 mov rdi,0
 mov rsi,cho
 mov rdx,2
 syscall



 cmp byte[cho],31h          ;; comparing choice
 je a

 cmp byte[cho],32h
 je b

       jmp exit

 a:  call Succe_addition

 jmp _start

 b:  call Add_shift

 jmp _start

exit:
 mov rax,60
 mov rdi,0
 syscall

convert:                              ;; ASCII to Hex conversion
 xor rbx,rbx
 xor rcx,rcx
 xor rax,rax

 mov rcx,02
 mov rsi,num
 up1:
 rol bl,04

 mov al,[rsi]
 cmp al,39h
 jbe p1
 sub al,07h
 jmp p2
 p1: sub al,30h
 p2: add bl,al
 inc rsi
```

```
 loop up1
ret

display:                ;; Hex to ASCII conversion
 mov rcx,4
 mov rdi,result
 dup1:
 rol bx,4
 mov al,bl
 and al,0fh
 cmp al,09h
 jbe p3
 add al,07h
 jmp p4
 p3: add al,30h
 p4:mov [rdi],al
 inc rdi
 loop dup1

       mov rax,1
 mov rdi,1
 mov rsi,result
 mov rdx,4
 syscall


ret


Succe_addition:

       mov rax,1
 mov rdi,1
 mov rsi,msg
 mov rdx,msg_len
 syscall



       mov rax,0
 mov rdi,0
 mov rsi,num
 mov rdx,3
 syscall
```

```
call convert
mov [num1],bl

      mov rax,1
mov rdi,1
mov rsi,msg
mov rdx,msg_len
syscall



      mov rax,0
mov rdi,0
mov rsi,num
mov rdx,3
syscall


call convert
xor rcx,rcx
xor rax,rax
mov rax,[num1]

repet:
add rcx,rax
dec bl
jnz repet

mov [result],rcx

      mov rax,1
mov rdi,1
mov rsi,res
mov rdx,res_len
syscall



mov rbx,[result]

call display
ret
```

```
Add_shift:

        mov rax,1
 mov rdi,1
 mov rsi,msg
 mov rdx,msg_len
 syscall



        mov rax,0
 mov rdi,0
 mov rsi,num
 mov rdx,3
 syscall



 call convert
 mov [num1],bl


        mov rax,1
 mov rdi,1
 mov rsi,msg
 mov rdx,msg_len
 syscall



        mov rax,0
 mov rdi,0
 mov rsi,num
 mov rdx,3
 syscall



 call convert

 mov [num],bl

 xor rbx,rbx
 xor rcx,rcx
 xor rdx,rdx
 xor rax,rax
```

```
mov dl,08
mov al,[num1]
mov bl,[num]

p11:
      shr bx,01
jnc p
add cx,ax
p:
      shl ax,01
dec dl
jnz p11

mov [result],rcx


      mov rax,1
mov rdi,1
mov rsi,res
mov rdx,res_len
syscall

;dispmsg res,res_len

mov rbx,[result]
call display

ret
```

OUTPUT:

```
;;Enter your Choice:
;;1.Successive Addition
;;2.Add and Shift method
;;3.Exit
;;1
;;Enter two digit Number::
;;02
;;Enter two digit Number::
;;02

;;Multiplication of elements is::0004Enter your Choice:
;;1.Successive Addition
;;2.Add and Shift method
```

;;3.Exit
;;2
;;Enter two digit Number::
;;03
;;Enter two digit Number::
;;03

;;Multiplication of elements is::0009Enter your Choice:
;;1.Successive Addition
;;2.Add and Shift method
;;3.Exit
;;3

CONCLUSION: In this practical session we learnt how to perform multiplication of two 8-bit hexadecimal numbers using successive addition and add and shift method.

EXPERIMENT NO. 10

NAME: Write x86 ALP to find the factorial of a given integer number on a command line by using recursion. Explicit stack manipulation is expected in the code.

AIM: Write x86 ALP to find the factorial of a given integer number on a command line by using recursion. Explicit stack manipulation is expected in the code.

OBJECTIVES:

- To understand assembly language programming instruction set.
- To understand different assembler directives with example.
- To apply instruction set for implementing X86/64 bit assembly language programs

ENVIRONMENT:

- Operating System: 64-bit Open source Linux or its derivative.
- Programming Tools: Preferably using Linux equivalent or MASM/TASM/NASM/FASM.
- Text Editor: geditor

THEORY:

A recursive procedure is one that calls itself. There are two kind of recursion: direct and indirect. In direct recursion, the procedure calls itself and in indirect recursion, the first procedure calls a second procedure, which in turn calls the first procedure.

Recursion could be observed in numerous mathematical algorithms. For example, consider the case of calculating the factorial of a number. Factorial of a number is given by the equation –

Fact (n) = n * fact (n-1) for n > 0

For example: factorial of 5 is 1 x 2 x 3 x 4 x 5 = 5 x factorial of 4 and this can be a good example of showing a recursive procedure. Every recursive algorithm must have an ending condition, i.e., the recursive calling of the program should be stopped when a condition is fulfilled. In the case of factorial algorithm, the end condition is reached when n is 0.

Recursion occurs when a procedure calls itself. The following for example is a recursive procedure:

```
Recursive proc
callRecursive
ret
Recursive  endp
```

Of course the CPU will never execute the ret instruction at the end of this procedure. Upon entry into Recursive this procedure will immediately call itself again and control will never pass to the ret instruction. In this particular case run away recursion results in an infinite loop.

In many respects recursion is very similar to iteration (that is the repetitive execution of a loop).

The following code also produces an infinite loop:

```
Recursive proc

jmp Recursive
ret
Recursive endp
```

There is however one major difference between these two implementations. The former version of Recursive pushes a return address onto the stack with each invocation of the subroutine. This does not happen in the example immediately above (since the jmp instruction does not affect the stack).

Like a looping structure recursion requires a termination condition in order to stop infinite recursion. Recursive could be rewritten with a termination condition as follows:

```
Recursive proc
dec ax
jzQuitRecurse
```

```
        call Recursive

        QuitRecurse: ret

        Recursiveendp
```

This modification to the routine causes Recursive to call itself the number of times appearing in the ax register. On each call Recursive decrements the ax register by one and calls itself again. Eventually Recursive decrements ax to zero and returns. Once this happens the CPU executes a string of ret instructions until control returns to the original call to Recursive.

So far however there hasn't been a real need for recursion. After all you could efficiently code this procedure as follows:

```
        Recursive proc

        RepeatAgain: dec ax

        jnzRepeatAgain

        ret

        Recursive endp
```

Both examples would repeat the body of the procedure the number of times passed in the ax register. As it turns out there are only a few recursive algorithms that you cannot implement in an iterative fashion. However many recursively implemented algorithms are more efficient than their iterative counterparts and most of the time the recursive form of the algorithm is much easier to understand.

ALGORITHM:

Step1: Start

Step2: Accept the number from user

Step3: Convert that number into Hexadecimal (ascii to hex)

Step4: Compare accepted number with 1. If it is equal to 1 go to step 5 else push the number on stack and decrement the number and go to step 4

Step5: pop the content of the stack and multiply with number

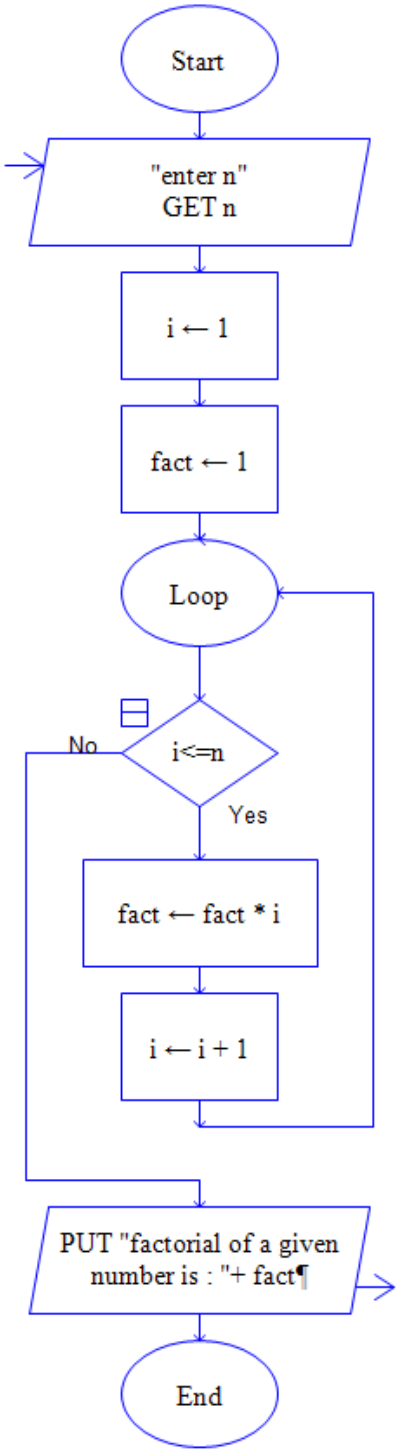
Step6: Repeat step until stack becomes empty

Step7: Convert number from Hex to ASCII

Step8: Print the number

Step9: Stop

FLOWCHART:


Start
"enter n"
GET n
i ← 1
fact ← 1
Loop
No
i<=n
Yes
fact ← fact * i
i ← i + 1
PUT "factorial of a given number is : "+ fact¶
End

PROGRAM:

```
section .data
msgFact: db 'Factorial is:',0xa
msgFactSize: equ $-msgFact
newLine: db 10
section .bss
fact: resb 8
num: resb 2

section .txt
global _start
_start:
 pop rbx ;Remove number of arguments
 pop rbx ;Remove the program name

 pop rbx ;Remove the actual number whoes factorial is to be calculated (Address of number)

 mov [num],rbx

 ;print number accepted from command line

 mov rax,1
 mov rdi,1
 mov rsi,[num]
 mov rdx,2
 syscall


 mov rsi,[num]
 mov rcx,02
 xor rbx,rbx
 call aToH

 mov rax,rbx

 call factP


 mov rcx,08
 mov rdi,fact
 xor bx,bx
 mov ebx,eax
 call hToA
```

```
 mov rax,1
 mov rdi,1
 mov rsi,newLine
 mov rdx,1
 syscall

 mov rax,1
 mov rdi,1
 mov rsi,fact
 mov rdx,8
 syscall

 mov rax,1
 mov rdi,1
 mov rsi,newLine
 mov rdx,1
 syscall

 mov rax,60
 mov rdi,0
 syscall

factP:
 dec rbx
 cmp rbx,01
 je comeOut
 cmp rbx,00
 je comeOut
 mul rbx
 call factP
comeOut:
 ret
aToH:
up1: rol bx,04
 mov al,[rsi]
 cmp al,39H
 jbe A2
 sub al,07H
A2: sub al,30H
 add bl,al
 inc rsi
 loop up1
ret


hToA:
```

```
   d:  rol ebx,4
mov ax,bx
and ax,0fH
cmp ax,09H
jbe ii
add ax,07H

ii: add ax,30H
mov [rdi],ax
inc rdi
loop d

ret
```

OUTPUT:

```
;nasm -f elf64 ass9_rec.asm
; ld -o ass9_rec ass9_rec.o
;./ass9_rec 02
;02
;00000002
```

CONCLUSION: In this practical session we learnt how to find the factorial of a given integer number on a command line by using recursion.

STUDY ASSIGNMENT

Motherboard -

A motherboard (sometimes manly known as the main board, system board) is the main printed circuit board (PCB) found in computer and other expanded systems. It heads many of the crucial electronic component of the system such as the Central Processing Unit (CPU) and memory and provides converter for other peripheral.

Main component of Motherboard are

- CPU Socket
- Memory Slots
- CMOS Battery
- ISA, PCI, and AGP slots
- Power Connector
- Chipset
- Graphical Devices
- Back Panel

CPU Socket-

CPU socket or CPU slot is a mechanical component that provides mechanical and electrical connections between a microprocessor and a PCB. It allows CPU to be replaced without soldering. Common socket have retention chips that apply a constant force which must be overcome. Then a device is inserted.

Memory Slot-

A memory slot, memory socket or RAM slot is what allows computer memory (RAM) to be inserted into the computer or motherboard, there will usually be 2-4 memory slots.

Types of RAMs-

1. DDR-RAM
2. DDR2-RAM
3. DDR3-RAM
4. DDR4-RAM
5. RD-RAM
6. SD-RAM
7. 72Pin-SIMM

CMOS Battery-

Non volatile BIOS memory space to a small memory on PC motherboard that is used to store BIOS setting. It was traditionally called CMOS RAM because it use a volatile low power complementary metal oxide semiconductor.

ISA-

Industry Standard Architecture is a 8 bit 16 bit parallel bus system that allows up to 6 devices to be connected to PC.

AGP-

Accelerate Graphics Part is high speed point to point channel to attaching a video card to computers motherboard.

PCI-

Peripheral Component Inter-connected bus uses a local bus system. This system is independent of the processor bus speed.

Power Connectors-

i. 20+4 pin
ii. SATA
iii. Floppy Connectors
iv. PCIE Connectors

Chipset-

A chipset is a set of electronic component which is an integral circuit that manages the data flow between the processor, memory and peripherals. It is usually designed to work with a specific family of microprocessors.

Graphical Devices-

A video card (also called a video adapter) is an expansion card which generates a feed of output images to display, such as computer monitor.