EL2003 Computer Organization & Assembly Language

Lab 10

Advanced Procedures

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LAB 10

Learning Objectives

- Implementing procedures using stack frame
- Using stack parameters in procedures
- Passing value type and reference type parameters

Stack Applications

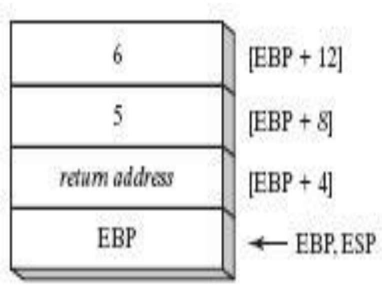
There are several important uses of runtime stacks in programs:

- A stack makes a convenient temporary save area for registers when they are used for more than one purpose. After they are modified, they *can* be restored to their original values.
- When the CALL instruction executes, the CPU saves the current subroutine's return address on the stack.
- When calling a subroutine, you pass input values called arguments by pushing them on the stack.
- The stack provides temporary storage for local variables inside subroutines.

Stack Parameters

- **Passing by value**
  When an argument is passed by value, a copy of the value is pushed on the stack.

EXAMPLE # 01:



```
.data
        var1    DWORD       5
        var2    DWORD       6

.code
        push var2
        push var1
        call AddTwo
        exit
AddTwo PROC
        push    ebp
        mov     ebp, esp
        mov     eax, [ebp  + 12]
        add     eax, [ebp + 8]
        pop     ebp
        ret
AddTwo ENDP
```

- **Explicit stack parameters**

When stack parameters are referenced with expressions such as [ebp+8], we call them explicit stack parameters.

EXAMPLE # 02:

```
.data
        var1    DWORD       5
        var2    DWORD       6

        y_param     EQU     [ebp + 12]
        x_param     EQU     [ebp+ 8]

.code
        push var2
        push var1
        call AddTwo
        exit

AddTwo PROC
        push    ebp
        mov     ebp, esp
        mov     eax, y_param
        add     eax, x_param
        pop     ebp
        ret
AddTwo ENDP
```

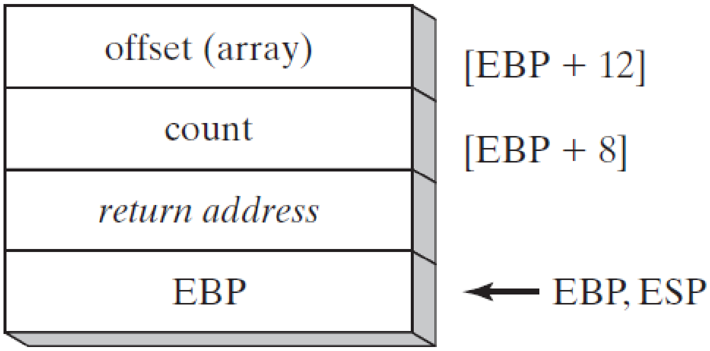
- **Passing by reference**

An argument passed by reference consists of the offset of an object to be passed.

EXAMPLE # 03:

```
.data
        count = 10
        arr     WORD            count DUP (?)

.code
        push    OFFSET arr
        push    count
        call    ArrayFill
```

```
 exit

ArrayFill       PROC
        push    ebp
        mov     ebp, esp
        pushad
        mov     esi, [ebp + 12]
        mov     ecx, [ebp + 8]
        cmp     ecx, 0
        je      L2

L1:
        mov     eax, 100h
        call    RandomRange
        mov     [esi], ax
        add     esi, TYPE WORD
        loop    L1
L2:
        popad
        pop     ebp
        ret     8
ArrayFill       ENDP
```



LEA Instruction

LEA instruction returns the effective address of an indirect operand. Offsets of indirect operands are calculated at runtime.

EXAMPLE # 04:

```
.code
        call    makeArray
        exit

makeArray       PROC
        push    ebp
        mov     ebp, esp
        sub     esp, 32
        lea     esi, [ebp - 30]
        mov ecx,30
L1:
        mov     BYTE PTR [esi], '*'
        inc     esi
        loop    L1
        add     esp, 32
        pop     ebp
        ret
makeArray       ENDP
```

ENTER & LEAVE Instructions

Enter instruction automatically creates stack frame for a called Procedure. Leave instruction reverses the effect of enter instruction.

EXAMPLE # 06:

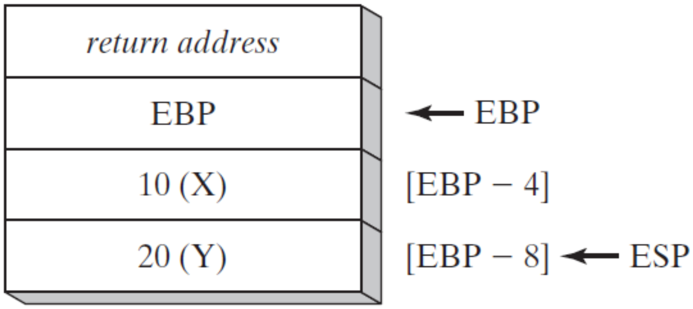
```
.data
        var1    DWORD       5
        var2    DWORD       6

.code
        push var2
        push var1
        call AddTwo
        exit


AddTwo PROC
        enter   0, 0
        mov     eax, [ebp  + 12]
        add     eax, [ebp + 8]
        pop     ebp
        leave
        ret
AddTwo ENDP
```

Local Variables

In MASM Assembly Language, local variables are created at runtime stack, below the base pointer (EBP).

EXAMPLE # 05:

```
.code
        call    MySub
        exit
```



```
MySub       PROC
        push    ebp
        mov     ebp, esp
        sub     esp, 8
        mov     DWORD       PTR     [ebp - 4], 10     ; first parameter
        mov     DWORD       PTR [ebp - 8], 20         ; second parameter
        mov     esp, ebp
        pop     ebp
        ret
MySub       ENDP
```

LOCAL Directive

LOCAL directive declares one or more local variables by name, assigning them size attributes.

EXAMPLE # 07:

```
.code
        call LocalProc
        exit


LocalProc   PROC
        LOCAL       temp : DWORD
        mov     temp, 5
        mov     eax, temp
        ret
LocalProc   ENDP
```

Recursive Procedures

Recursive procedures are those that call themselves to perform some task.

EXAMPLE # 08:

```
.code
        mov     ecx, 5
        mov     eax, 0
        call    CalcSum
L1:
```

```
            call    WriteDec
            call    crlf
            exit

    CalcSum         PROC
            cmp     ecx, 0
            jz      L2
            add     eax, ecx
            dec     ecx
            call    CalcSum
    L2:
            ret
    CalcSum         ENDP
```

- ## INVOKE Directive

The INVOKE directive pushes arguments on the stack and calls a procedure. INVOKE is a convenient replacement for the CALL instruction because it lets you pass multiple arguments using a single line of code.
Here is the general syntax:
INVOKE procedureName [, argumentList]

Using the CALL instruction, for example, we could call a procedure named DumpArray after executing several PUSH instructions:

```
push TYPE array
push LENGTHOF array
push OFFSET array
call DumpArray
```

The equivalent statement using INVOKE is reduced to a single line in which the arguments are listed in reverse order.
INVOKE DumpArray, OFFSET array, LENGTHOF array, TYPE array

- ### ADDR Operator

The ADDR operator can be used to pass a pointer argument when calling a procedure using INVOKE. The following INVOKE statement, for example, passes the address of myArrayto the FillArrayprocedure:

```
INVOKE FillArray, ADDR myArray
```

- ## PROC Directive

Syntax of the PROC Directive
The PROC directive has the following basic syntax:

```
Label PROC [attributes] [USES reglist], parameter_list
```

The PROC directive permits you to declare a procedure with a comma-separated list of named parameters.

Example: The FillArray procedure receives a pointer to an array of bytes:

```
    FillArray PROC,

    pArray:PTR BYTE

    . . .

    FillArray ENDP
```

- **PROTO Directive**

The PROTO directive creates a prototype for an existing procedure. A prototype declares a procedure’s name and parameter list. It allows you to call a procedure before defining it and to verify that the number and types of arguments match the procedure definition.

```
MySub PROTO         ; procedure prototype
.
INVOKE MySub        ; procedure call
.
MySub PROC          ; procedure implementation
.
.
MySub ENDP
```

ACTIVITIES:

1. Write a program which contains a procedure named **ThreeProd** that displays the product of three numeric parameters passed through a stack.

2. Write a program which contains a procedure named **TakeInput** which takes input numbers from user and call a procedure named **GCD** which calculates their GCD and display the answer on console by calling another function **Display**. (Also show ESP values during nested function calls)

2. Write a program which contains a procedure named **MinMaxArray** that displays the minimum & maximum values in an array. Pass a size-20 array by reference to this procedure.

3. Write a program which contains a procedure named **LocalSquare** . The procedure must declare a local variable. Initialize this variable by taking an input value from the user and then display its square. Use **ENTER *& LEAVE*** instructions to allocate and de-allocate the local variable.

4. Write a program that calculates factorial of a given number ***n***. Make a recursive procedure named **Fact** that takes n as an input parameter.

5. Write a non-recursive version of the procedure **Fact** that uses a loop to calculate factorial of given number n. Compare efficiency of both versions of the **Fact** procedure using **GetMSeconds**.

6. Write a program to take 4 input numbers from the users. Then make two procedures **CheckPrime** and **LargestPrime**. The program should first check if a given number is a prime number or not. If all of the input numbers are prime numbers then the program should call the procedure LargestPrime.

CheckPrime: This procedure tests if a number is prime or not
LargestPrime: This procedure finds and displays the largest of the four prime numbers.

7. Write a program which contains a procedure named BubbleSort that sorts an array which is passed through a stack using indirect addressing.

8. Write a program which contains a procedure named TakeInput which takes input numbers from user and call a procedure named Armstrong which checks either a number is an Armstrong number or not and display the answer on console by calling anotherfunction Display. (Also show ESP values during nested function calls)