Computer Organization and Assembly Language (EL-2003)

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Section: BCS-3D / BCS-3H
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LAB # 10

Advanced Procedures

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:

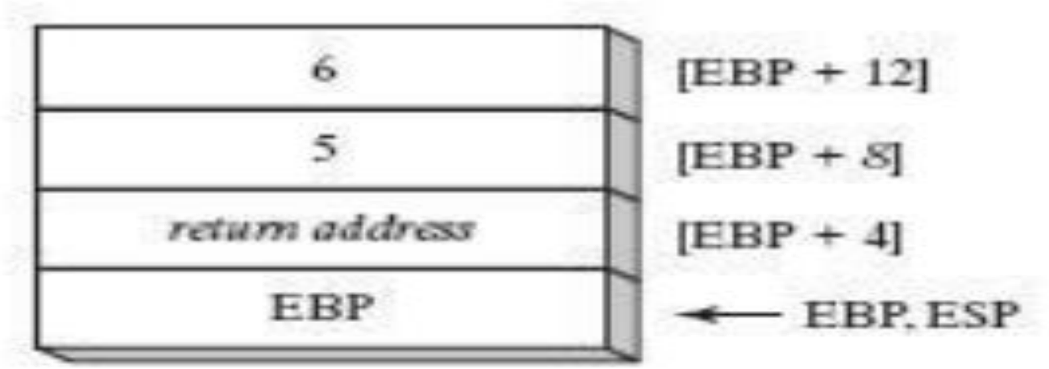
- A stack makes a convenient temporary save area for registers when they are used for more than one purpose. After they are modified, they can be restored to their original values.
- When the CALL instruction executes, the CPU saves the current subroutine's return address on the stack.
- When calling 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:

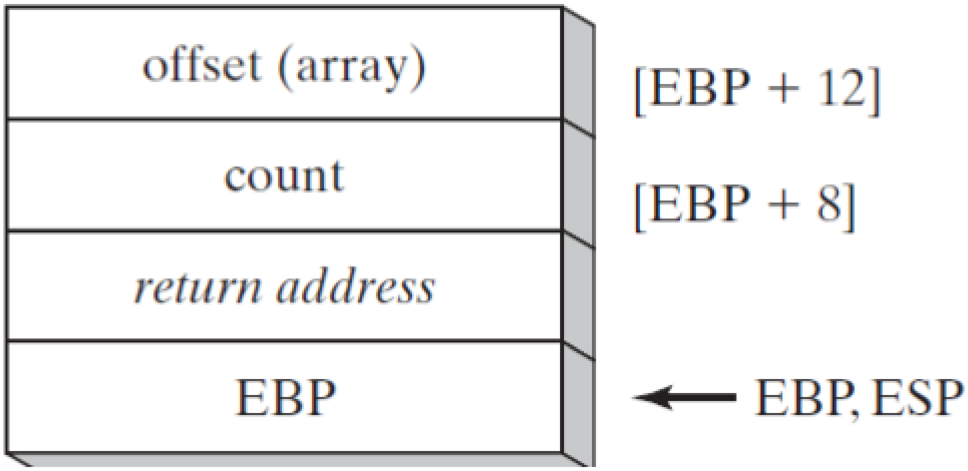
An argument passed by reference consists of the offset of an object to be passed.

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                 ; Reserves 32 bytes of local space on the stack
lea esi, [ebp - 30]         ; Loads the address of the local array into ESI
mov ecx,30                  ; Sets a loop counter
L1:
 mov BYTE PTR [esi], '*'
 inc esi
loop L1
 add esp, 32                ; frees the local 32 bytes
 pop ebp                    ; restore old base pointer
 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:

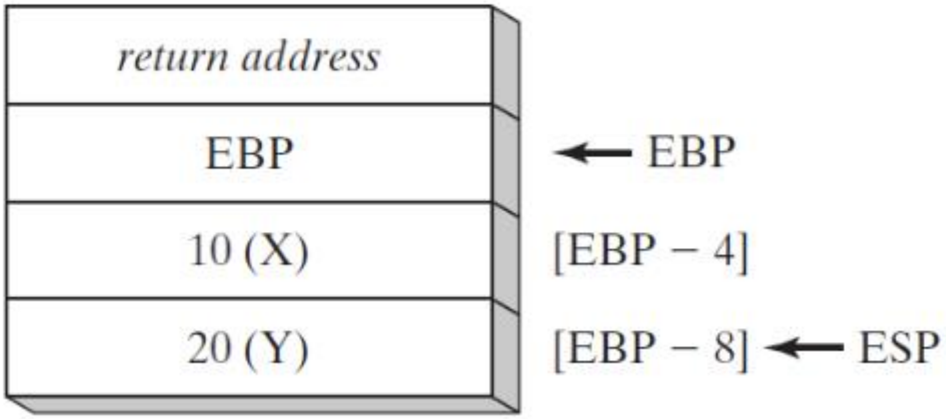
```
.data
 var1 DWORD 5
 var2 DWORD 6
.code
 push var2
 push var1
 call AddTwo
 exit
AddTwo PROC
enter 0, 0
mov eax, [ebp  + 12]
add eax, [ebp + 8]
leave
ret
AddTwo ENDP
```

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
```

→

```
FillArray PROC
   push ebp
   mov  ebp, esp
   mov  esi, [ebp + 8]
```

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
```