# Macros and Conditional Assembly

Chapter 10

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# Outline

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- Macros with parameters
- Macros vs procedures
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- Macro operators
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- Nested macros
- Performance: Macros vs procedures

# What Are Macros?

- Macros provide a means to represent a block of text (code, data, etc.) by a name (*macro name*)
- Macros provide a sophisticated text substitution mechanism
- Three directives
  - ∗ =

    Example: **`CLASS_SIZE = 90`** (can be redefined later)
  - ∗ EQU
    - » Example: **`CLASS_SIZE   EQU   90`**
  - ∗ MACRO

# What Are Macros? (cont’d)

- Macros can be defined with MACRO and ENDM
- Format

```
macro_name   MACRO [parameter1, parameter2, ...]
             macro body
             ENDM
```

- A macro can be invoked using

```
macro_name [argument1, argument2, …]
```

Example: Definition Invocation

```
multAX_by_16    MACRO          |       ...
                sal     AX,4   |  mov   AX,27
                ENDM           |  multAX_by_16
                               |       ...
```

# Macros with Parameters

- Macros can be defined with parameters
  - » More flexible
  - » More useful
- Example

```
mult_by_16    MACRO   operand
              sal     operand,4
              ENDM
```

∗ To multiply a byte in DL register

```
mult_by_16    DL
```

∗ To multiply a memory variable **`count`**

```
mult_by_16    count
```

# Macros with Parameters (cont'd)

Example: To exchange two memory words

```
Wmxchg   MACRO  operand1, operand2
         xchg   AX,operand1
         xchg   AX,operand2
         xchg   AX,operand1
         ENDM
```

Example: To exchange two memory bytes

```
Bmxchg   MACRO  operand1, operand2
         xchg   AL,operand1
         xchg   AL,operand2
         xchg   AL,operand1
         ENDM
```

# Macros vs. Procedures

- Similar to procedures in some respects
  - ∗ Both improve programmer productivity
  - ∗ Aids development of modular code
  - ∗ Can be used when a block of code is repeated in the source program
- Some significant differences as well
  - ∗ Parameter passing
  - ∗ Types of parameters
  - ∗ Invocation mechanism

# Macros vs. Procedures (cont'd)

**Parameter passing**

- In macros, similar to a procedure call in a HLL

```
mult_by_16    AX
```

- In procedures, we have to push parameters onto the stack

```
push    AX
call    times16
```

- Macros can avoid
  - ∗ Parameter passing overhead
    - – Proportional to the number of parameters passed
  - ∗ **`call/ret`** overhead

# Macros vs. Procedures (cont’d)

## Types of parameters

- Macros allow more flexibility in the types of parameters that can be passed
  - Result of it being a text substitution mechanism

**Example**

```
shift    MACRO    op_code,operand,count
         op_code  operand,count
         ENDM
```

can be invoked as

```
shift    sal,AX,3
```

which results in the following expansion

```
sal    AX,3
```

# Macros vs. Procedures (cont’d)

## Invocation mechanism

- ∗ Macro invocation
  - » Done at assembly time by text substitution
- ∗ Procedure invocation
  - » Done at run time

- Tradeoffs

| **Type of overhead** | **Procedure** | **Macro** |
|---|---|---|
| Memory space | lower | higher |
| Execution time | higher | lower |
| Assembly time | lower | higher |

# When Are Macros Better?

- Useful to extend the instruction set by defining macro-instructions

```
times16    PROC
           push   BP
           mov    BP,SP
           push   AX
           mov    AX,[BP+4]
           sal    AX,4
           mov    [BP+4],AX
           pop    AX
           pop    BP
           ret    2
times16    ENDP
```

Invocation

```
push    count
call    times16
pop     count
```

Too much overhead

Use of procedure is impractical

# When Are Macros Better? (cont’d)

- Sometimes procedures cannot be used
  - » Suppose we want to save and restore BX, CX, DX, SI, DI, and BP registers
  - » Cannot use **`pusha`** and **`popa`** as they include AX as well

```
save_regs  MACRO               restore_regs  MACRO
           push   BP                         pop    BX
           push   DI                         pop    CX
           push   SI                         pop    DX
           push   DX                         pop    SI
           push   CX                         pop    DI
           push   BX                         pop    BP
           ENDM                              ENDM
```

# Labels in Macros

- Problem with the following macro definiton

```
to_upper0    MACRO    ch
             cmp    ch,'a'
             jb     done
             cmp    ch,'z'
             ja     done
             sub    ch,32
       done:
             ENDM
```

  * If we invoke it more than once, we will have duplicate label **done**

# Labels in Macros (cont’d)

- Solution: Use LOCAL directive
- Format: `LOCAL  local_label1 [,local_label2,…]`

```
to_upper    MACRO  ch
            LOCAL  done
            cmp    ch,'a’
            jb     done
            cmp    ch,'z’
            ja     done
            sub    ch,32
     done:
            ENDM
```

Assembler uses labels

**??XXXX**

where **XXXX** is between 0 and FFFFH

To avoid conflict, do not use labels that begin with **??**

# Comments in Macros

- We don’t want comments in a macro definition to appear every time it is expanded
    - » The ;; operator suppresses comments in the expansions

```
;;Converts a lowercase letter to uppercase.
to_upper  MACRO   ch
        LOCAL   done
        ; case conversion macro
        cmp     ch,'a'  ;; check if ch >= 'a'
        jb      done
        cmp     ch,'z'  ;;   and if ch >= 'z'
        ja      done
        sub     ch,32   ;; then ch := ch - 32
done:
        ENDM
```

# Comments in Macros (cont’d)

- Invoking the **`to_upper`** macro by

```
mov      AL,'b'
to_upper   AL
mov      BL,AL
mov      AH,'1'
to_upper   AH
mov      BH,AH
```

generates the following macro expansion

# Comments in Macros (cont’d)

```
     17 0000  B0 62                  mov     AL,'b'
     18                              to_upper   AL
1    19                              ; case conversion macro
1    20 0002  3C 61                  cmp     AL,'a'
1    21 0004  72 06                  jb      ??0000
1    22 0006  3C 7A                  cmp     AL,'z'
1    23 0008  77 02                  ja      ??0000
1    24 000A  2C 20                  sub     AL,32
1    25 000C                  ??0000:
     26 000C  8A D8                  mov     BL,AL
     27 000E  B4 31                  mov     AH,'1'
```

# Comments in Macros (cont’d)

```
     28                              to_upper   AH
1    29                              ; case conversion macro
1    30 0010  80 FC 61               cmp     AH,'a'
1    31 0013  72 08                  jb      ??0001
1    32 0015  80 FC 7A               cmp     AH,'z'
1    33 0018  77 03                  ja      ??0001
1    34 001A  80 EC 20               sub     AH,32
1    35 001D                  ??0001:
     36 001D  8A FC                  mov     BH,AH
```

# Macro Operators

- Five operators

| | |
|---|---|
| ;; | Suppress comment |
| & | Substitute |
| < > | Literal-text string |
| ! | Literal-character |
| % | Expression evaluate |

  - ∗ We have already seen ;; operator
  - ∗ We will discuss the remaining four operators

# Macro Operators (cont’d)

## Substitute operator (&)

- Substitutes a parameter with the actual argument

- Syntax: **&name**

```
sort2    MACRO  cond, num1, num2
         LOCAL   done
         push    AX
         mov     AX,num1
         cmp     AX,num2
         j&cond  done
         xchg    AX,num2
         mov     num1,AX
    done:
         pop     AX
         ENDM
```

# Macro Operators (cont’d)

- To sort two unsigned numbers **`value1`** and **`value2`**, use

  ```
  sort2    ae,value1,value2
  ```

  generates the following macro expansion

```
push    AX
        mov      AX,value1
        cmp      AX,value2
        jae      ??0000
        xchg     AX,value2
        mov      value1,AX
 ??0000:
        pop      AX
```

- To sort two signed numbers **`value1`** and **`value2`**, use

  ```
  sort2    ge,value1,value2
  ```

# Macro Operators (cont'd)

## Literal-text string operator (< >)

- ∗ Treats the enclosed text as a single string literal rather than separate arguments
- ∗ Syntax: **`<text>`**

```
range_error1    MACRO    number,variable,range
err_msg&number    DB   '&variable: out of range',0
range_msg&number  DB   'Correct range is &range',0
                ENDM
```

- Invoking with

```
range_error1    1,<Assignment mark>,<0 to 25>
```

produces

```
err_msg1    DB   'Assignment mark: out of range',0
range_msg1  DB   'Correct range is 0 to 25',0
```

# Macro Operators (cont’d)

## Literal-character operator (!)

- ∗ Treats the character literally without its default meaning
- ∗ Syntax: **`!character`**

```
range_error2    MACRO    number,variable,range
err_msg&number  DB  '&variable: out of range - &range',0
                ENDM
```

- Invoking with

```
range_error2    3,mark,<can!'!'t be !> 100>
```

produces

```
err_msg3   DB   'mark: out of range - can''t be > 100',0
```

- ∗ Without the ! operator, two single quotes will produce a single quote in the output

# Macro Operators (cont'd)

## Expression Evaluate operator (%)

- ∗ Expression is evaluated and its value is used to replace the expression itself
- ∗ Syntax: **`%expression`**

```
init_arry  MACRO  element_size,name,size,init_value
name   D&element_size   size DUP (init_value)
           ENDM
```

- Assuming `NUM_STUDENTS    EQU    47`

```
NUM_TESTS       EQU     7
```

Invoking with

```
    init_array   W,marks,%NUM_STUDENTS*NUM_TESTS,-1
```

produces

```
    marks    DW    329 DUP (-1)
```

# List Control Directives

- Control the contents of **`.LST`** file
- Two directives control the source lines

  **`.LIST`** Allows listing of subsequent source lines

  Default mode

  **`.XLIST`** Suppresses listing of subsequent source lines

- Macro invocation call directives

  **`.LALL`** Enables listing of macro expansions

  **`.SALL`** Suppresses listing of all statements in macro expansions

  **`.XALL`** Lists only the source statements in a macro expansion that generates code or data

# Repeat Block Directives

- Three directives to repeat a block of statements
  - **REPT**
  - **WHILE**
  - **IRP/IRPC**
- Mostly used to define and initialize variables in a data segment
- Each directive identifies the beginning of a block
  - ENDM indicates the end of a repeat block

# Repeat Block Directives (cont'd)

## REPT directive

- Syntax:

```
REPT expression
    macro-body
ENDM
```

  - ∗ **`macro-body`** is repeated **`expression`** times

```
mult_16  MACRO   operand
         REPT 4
           sal  operand,1
         ENDM
         ENDM
```

```
mult_16  MACRO   operand
         sal  operand,1
         sal  operand,1
         sal  operand,1
          sal  operand,1
         ENDM
```

# Repeat Block Directives (cont'd)

WHILE directive

- Syntax:

```
      WHILE expression
          macro-body
      ENDM
```

  - **macro-body** is executed until **expression** is false (0)

- Following code produces cubed data table

```
WHILE int_value LT NUM_ENTRIES
    DW   int_value*int_value*int_value
    int_value = int_value+1
ENDM
```

# Repeat Block Directives (cont'd)

IRP and IRPC directives

IRP - Iteration RePeat

IRPC - Iteration RePeat with Character substitution

- IRP directive
- Syntax:

```
IRP parameter,<argument1[,argument2,…]>
    macro-body
ENDM
```

  - ∗ Angle brackets are required
  - ∗ Arguments are gives as a list separated by commas
    - » During the first iteration **`argument1`** is assigned to **`parameter`**, **`argument2`** during the second iteration, ...

# Repeat Block Directives (cont'd)

**IRP example**

```
.DATA
IRP value, <9,6,11,8,13>
    DB   value
ENDM
```

produces

```
.DATA
DB    9
DB    6
DB    11
DB    8
DB    13
```

# Repeat Block Directives (cont'd)

- IRPC directive
- Syntax:

```
IRPC parameter, string
    macro-body
ENDM
```

  - ∗ **`macro-body`** is repeated once for each character in **`string`**
  - ∗ **`string`** specifies
    - » the number of iterations
    - » the character to be used in each iteration
  - ∗ During the first iteration first character of **`string`** is assigned to **`parameter`**, second character during the second iteration, ...

# Repeat Block Directives (cont'd)

- IRPC example
  - ∗ To generate a sequence of DB statements in the order a, A, e, E, …

```
defineDB  MACRO  value
DB    value
ENDM

IRPC   char, aeiou
defineDB '&char'
defineDB %'&char'-32
ENDM
```

  - ∗ Can also use

```
      IRP    char, <a,e,i,o,u>
```

in place of **IRPC** statement

# Conditional Assembly

- Several conditional directives are available

| | |
|---|---|
| IF/IFE | Assembles if condition is true (IF) or false (IFE) |
| IFDEF/IFNDEF | Assembles if symbol is defined (IFDEF) or undefined (IFNDEF) |
| IFB/IFNB | Assembles if arguments are blank (IFB) or not blank (IFNB) |
| IFIDN/IFDIF | Assembles if arguments are same (IFIDN) or different (IFDIF) - case sensitive |
| IFIDNI/IFDIFI | Assembles if arguments are same (IFIDNI) or different (IFDIFI) - case insensitive |

# Nested Macros

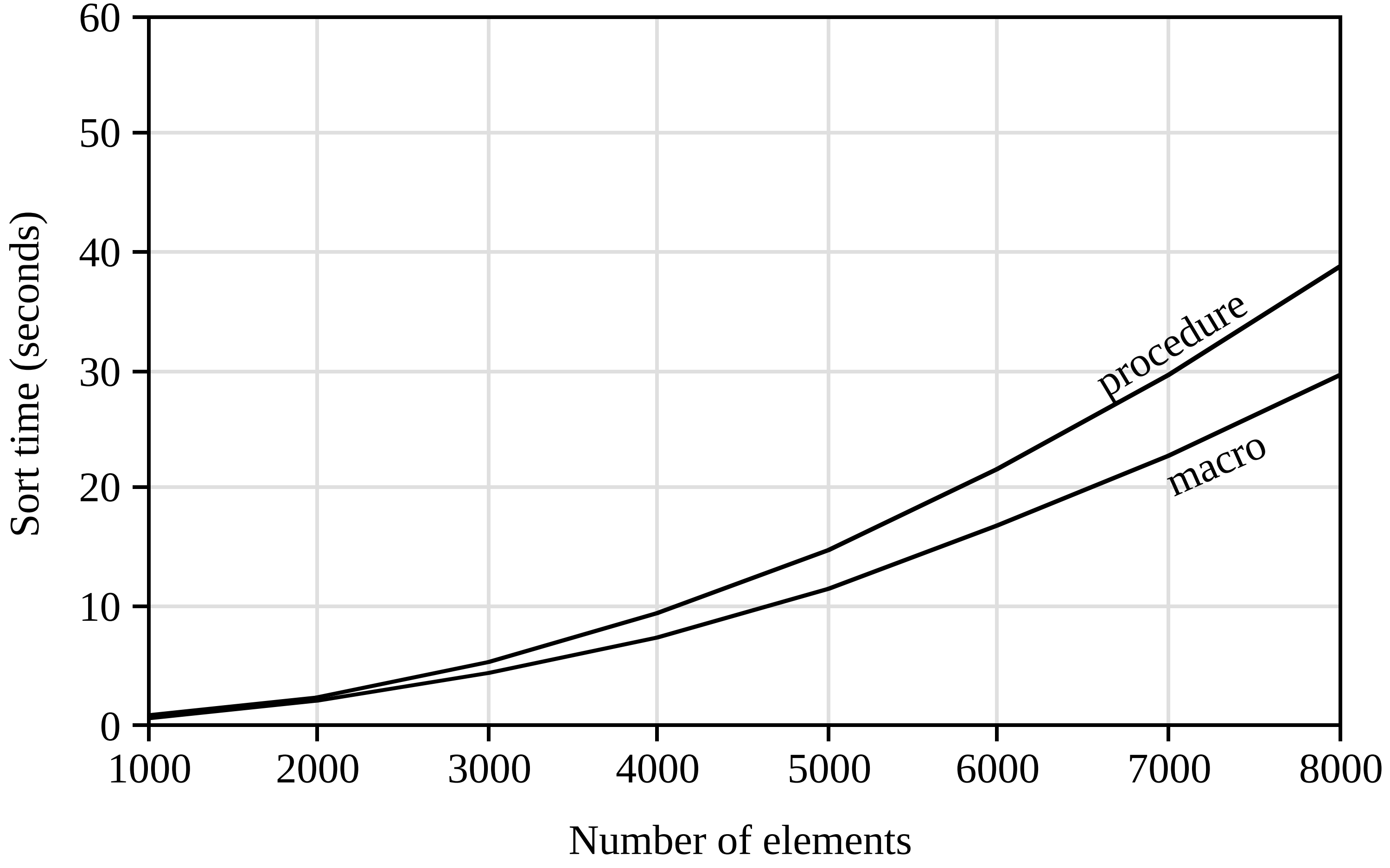
- Macros can be nested

```
shifty  MACRO   lr,operand,count
        IF PROC_TYPE EQ 8086
           IF count LE 4
              REPT count
              sh&lr   operand,1
              ENDM
           ELSE
              mov   CL,count
              sh&lr   operand,CL
           ENDIF
        ELSE
           sh&lr    operand,count
        ENDIF
        ENDM
```

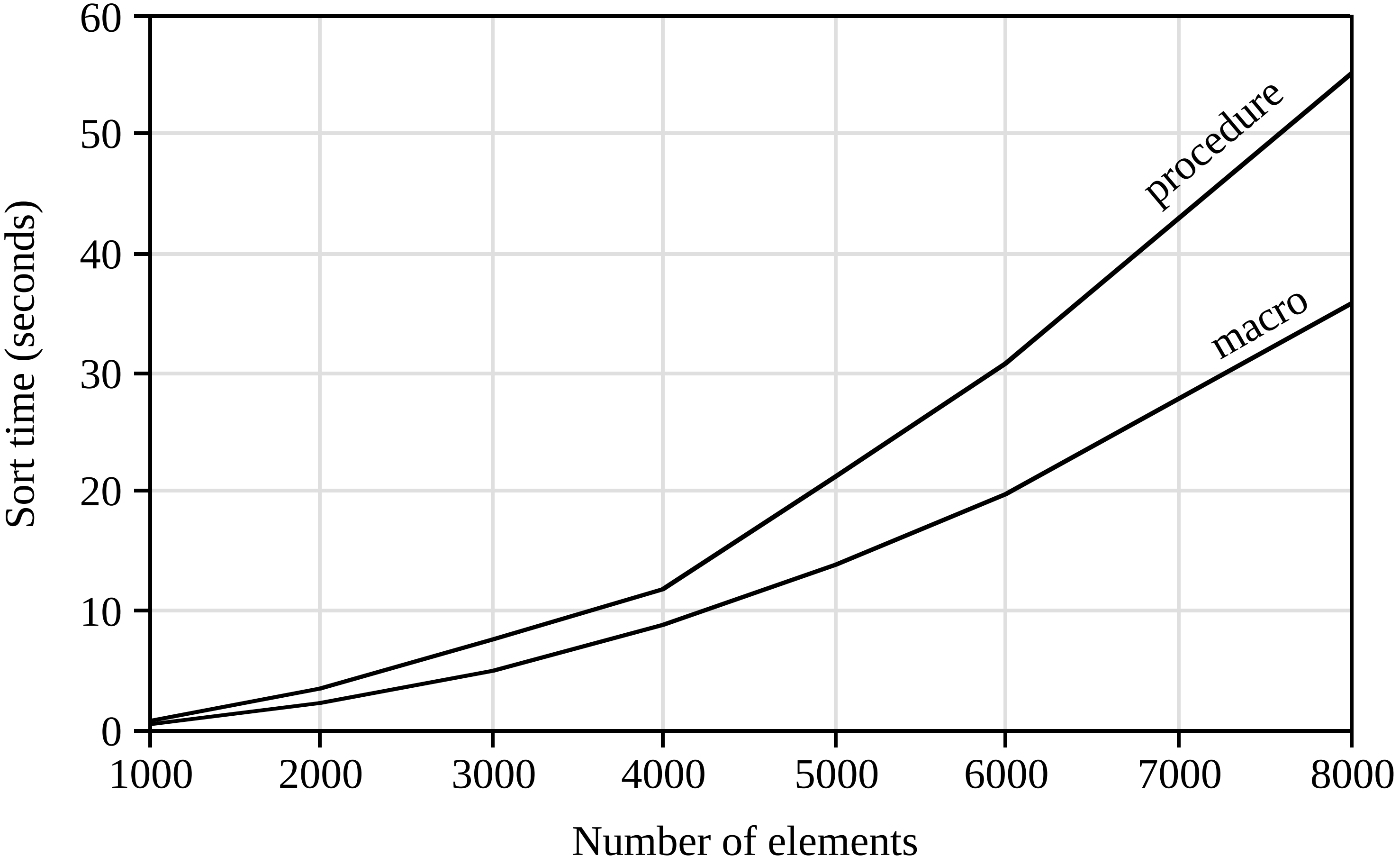
# Nested Macros (cont’d)

```
shift   MACRO   operand,count
        ;; positive count => left shift
        ;; negative count => right shift
        IFE count EQ 0
            IF count GT 0     ;; left shift
               shifty  l,operand,count
            ELSE              ;; right shift
               ;; count negative
               shifty  r,operand,-count
            ENDIF
        ENDIF
        ENDM
```

# Performance: Macros vs Procedures



# Performance: Macros vs Procedures (cont'd)


Sort time (seconds)
procedure
macro
Number of elements