
Macros and Conditional Assembly

Chapter 10
S. Dandamudi

Outline

- What are macros?
- Macros with parameters
- Macros vs procedures
 - * Parameter passing
 - * Types of parameters
 - * Invocation mechanism
 - * When are macros better?
- Labels in macros
- Comments in macros
- Macro operators
- List control directives
- Repeat block directives
 - * REPT directive
 - * WHLE directive
 - * IRP and IRPC directives
- Conditional assembly
 - * IF and IFE
 - * IFDEF and IFNDEF
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 - * IFIDN and IFDIF
- 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

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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:	<u>Definition</u>	<u>Invocation</u>
	<pre>multAX_by_16 MACRO sal AX,4 ENDM</pre>	<pre>... mov AX,27 multAX_by_16 ...</pre>

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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

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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

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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
```

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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

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When Are Macros Better?

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

<pre>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</pre>	<p style="text-align: center;">Invocation</p> <pre>push count call times16 pop count</pre>
---	--

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

<pre>save_regs MACRO push BP push DI push SI push DX push CX push BX ENDM</pre>	<pre>restore_regs MACRO pop BX pop CX pop DX pop SI pop DI pop BP ENDM</pre>
---	--

Labels in Macros

- Problem with the following macro definition

```
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**

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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 ??

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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
```

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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

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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'
```

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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
```

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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
```

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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
```

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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

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Macro Operators (cont'd)

Expression Evaluate operator (%)

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

```
init_array  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)
```

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## List Control Directives

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- 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

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## Repeat Block Directives

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- 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

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## Repeat Block Directives (cont'd)

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### REPT directive

- Syntax:

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

\* **macro-body** is repeated **expression** times

|                                                                     |                                                                                                               |
|---------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------|
| <pre>mult_16 MACRO operand REPT 4     sal operand,1 ENDM ENDM</pre> | <pre>mult_16 MACRO operand     sal operand,1     sal operand,1     sal operand,1     sal operand,1 ENDM</pre> |
|---------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------|

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## Repeat Block Directives (cont'd)

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### 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
```

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## Repeat Block Directives (cont'd)

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### 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 given as a list separated by commas

- » During the first iteration **argument1** is assigned to **parameter**,  
**argument2** during the second iteration, ...

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## Repeat Block Directives (cont'd)

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### 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
```

---

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## Repeat Block Directives (cont'd)

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- 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, ...

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## Repeat Block Directives (cont'd)

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- 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

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## Conditional Assembly

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- Several conditional directives are available

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

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## Nested Macros

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- 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
```

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## 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
```

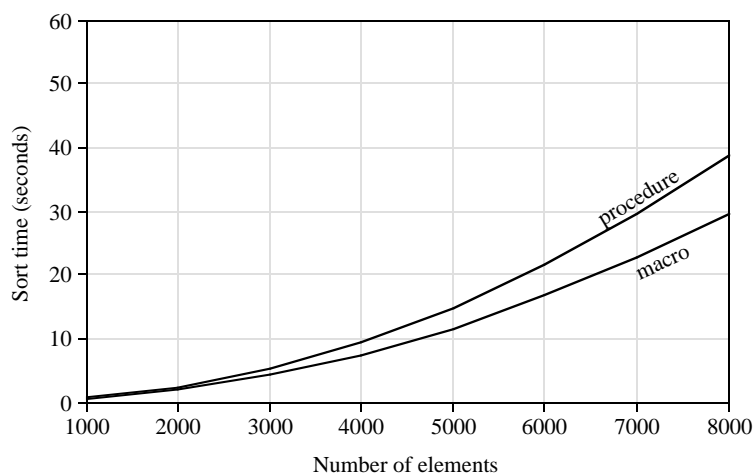
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## Performance: Macros vs Procedures



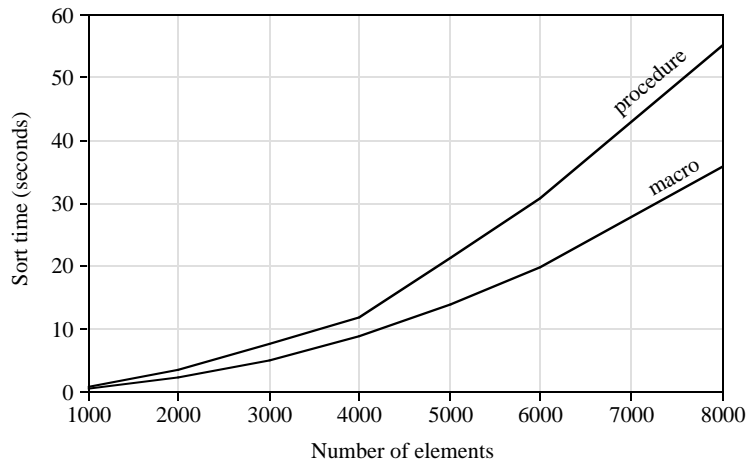
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