LAB 03

Data and its Types, Definition statement & Assembly Instructions

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Lab Session 03: Data & it's type, Definition statement & Assembly Instructions

Objectives:

- Introduction to Registers
- Defining Data
- Data Definition Statement
- Data Initializations
- Multiple Initializations
- String Initialization
- Assembly language Instructions: MOV, ADD, SUB
- Sample Program

Introduction to Registers

To speed up the processor operations, the processor includes some internal memory storage locations, called Registers. The registers store data elements for processing without having to access the memory.

Processor Registers

There are ten 32-bit and six 16-bit processor registers in IA-32 architecture.
The registers are grouped into three categories:

- General registers,
- Control registers, and
- Segment registers.

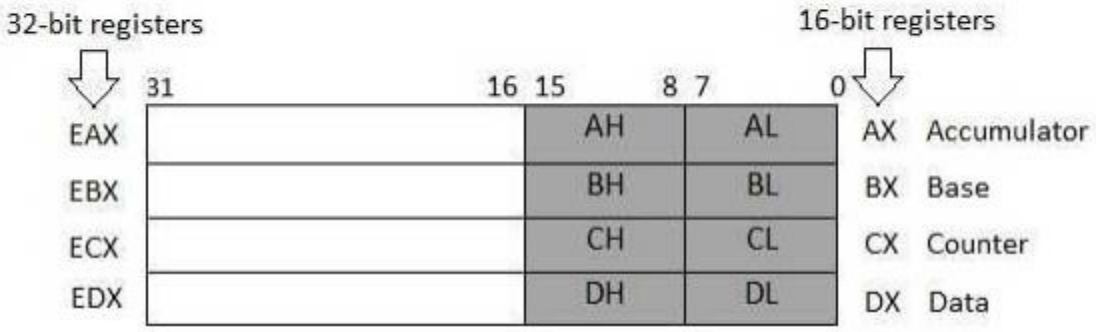
Furthermore, the general registers are further divided into the following groups:

- Data registers,
- Pointer registers &
- Index registers

Data Registers

Four 32-bit data registers are used for arithmetic, logical, and other operations. These 32-bit registers can be used in three ways:

- As complete 32-bit data registers: EAX, EBX, ECX, EDX.
- Lower halves of the 32-bit registers can be used as four 16-bit data registers: AX, BX, CX and DX.
- Lower and higher halves of the above-mentioned four 16-bit registers can be used as eight 8-bit data registers: AH, AL, BH, BL, CH, CL, DH, and DL.



AX (Accumulator): It is used in input/output and most arithmetic instructions. For example, in multiplication operation, one operand is stored in EAX or AX or AL register according to the size of the operand.

BX (Base register): It could be used in indexed addressing.

CX (Counter register): The ECX, CX registers store the loop count in iterative operations.

DX (Data register): It is also used in input/output operations. It is also used with AX register along with DX for multiply and division operations involving large values.

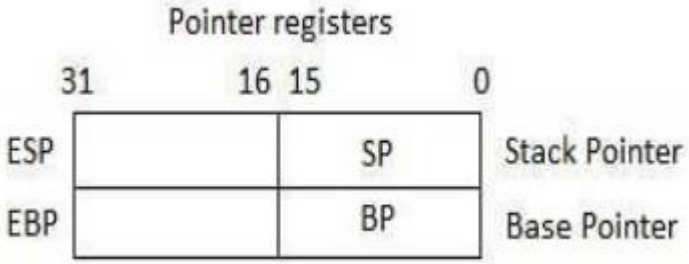
Pointer Registers

The pointer registers are 32-bit EIP, ESP, and EBP registers and corresponding 16-bit right portions IP, SP, and BP. There are three categories of pointer registers:

Instruction Pointer (IP): The 16-bit IP register stores the offset address of the next instruction to be executed. IP in association with the CS register (as CS:IP) gives the complete address of the current instruction in the code segment.

Stack Pointer (SP): The 16-bit SP register provides the offset value within the program stack. SP in association with the SS register (SS:SP) refers to be current position of data or address within the program stack.

Base Pointer (BP): The 16-bit BP register mainly helps in referencing the parameter variables passed to a subroutine. The address in SS register is combined with the offset in BP to get the location of the parameter. BP can also be combined with DI and SI as base register for special addressing.

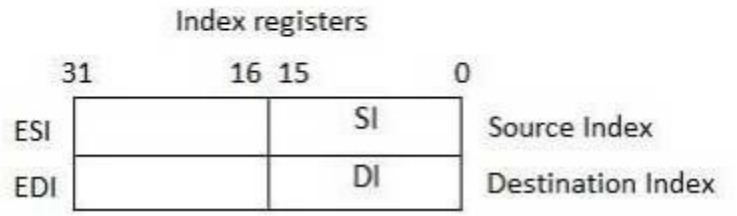


Index Registers

The 32-bit index registers, ESI and EDI, and their 16-bit rightmost portions. SI and DI, are used for indexed addressing and sometimes used in addition and subtraction. There are two sets of index pointers.

Source Index (SI): It is used as source index for string operations.

Destination Index (DI): It is used as destination index for string operations.



Data Types:

MASM defines **intrinsic data types**, each of which describes a set of values that can be assigned to variables and expressions of the given type.

BYTE	8-bit unsigned integer
SBYTE	8-bit signed integer. S stands for signed
WORD	16-bit unsigned integer
SWORD	16-bit signed integer
DWORD	32-bit unsigned. D stands for double
QWORD	64-bit integer. Q stands for quad
TBYTE	80-bit integer. T stands for ten

Data definition statement:

A data definition statement sets aside storage in memory for a variable, with an optional name.
Data definition statements create variables based on intrinsic data types.
A data definition has the following syntax:

[name] directive initializer [,initializer]...

Initializer: At least one initializer is required in a data definition, even if it is zero. Additional initializers, if any, are separated by commas. For integer data types, initializer is an integer constant or expression matching the size of the variable's type, such as BYTE or WORD. If you prefer to leave the variable uninitialized (assigned a random value), the ? symbol can be used as the initializer.

Examples:

```
value1 BYTE 'A'                          ; character constant
value2 BYTE 0                            ; smallest unsigned byte
value3 BYTE 255                          ; largest unsigned byte
value4 SBYTE −128                        ; smallest signed byte
value5 SBYTE +127                        ; largest signed byte
greeting1 BYTE "Good afternoon", 0       ; String constant
greeting2 BYTE 'Good night' ,0           ; String constant

list BYTE 10,20,30,40                    ; Multiple initializers
```

Note: A question mark (?) initializer leaves the variable uninitialized, implying it will be assigned a

value at runtime:

value6 BYTE ?

Activity:
Write a data declaration for an 8-bit unsigned integer and store 10 in it. Move this value to AL and add 40 to it.

DUP Operator

The DUP operator allocates storage for multiple data items, using a constant expression as a counter. It is particularly useful when allocating space for a string or array, and can be used with initialized or uninitialized data.

Examples:

```
v1 BYTE 20 DUP(0)              ; 20 bytes, all equal to zero
v2 BYTE 20 DUP(?)              ; 20 bytes, uninitialized
v3 BYTE 4 DUP("STACK")         ;20 bytes, "STACKSTACKSTACKSTACK"
```

Operand Types:

As x86 instruction formats:

[label:] mnemonic [operands][; comment]

Because the number of operands may vary, we can further subdivide the formats to have zero, one, two, or three operands.

Here, we omit the label and comment fields for clarity:

mnemonic
mnemonic [destination]
mnemonic [destination],[source]
mnemonic [destination],[source-1],[source-2]

x86 assembly language uses different types of instruction operands. The following are the easiest to use:

- Immediate—uses a numeric literal expression
- Register—uses a named register in the CPU
- Memory—references a memory location

Following table lists a simple notation for operands. We will use it from this point on to describe the syntax of individual instructions.

Operand	Description
reg8	8-bit general-purpose register: AH, AL, BH, BL, CH, CL, DH, DL
reg16	16-bit general-purpose register: AX, BX, CX, DX, SI, DI, SP, BP
reg32	32-bit general-purpose register: EAX, EBX, ECX, EDX, ESI, EDI, ESP, EBP
reg	Any general-purpose register
sreg	16-bit segment register: CS, DS, SS, ES, FS, GS
imm	8-, 16-, or 32-bit immediate value
imm8	8-bit immediate byte value
imm16	16-bit immediate word value
imm32	32-bit immediate doubleword value
reg/mem8	8-bit operand, which can be an 8-bit general register or memory byte
reg/mem16	16-bit operand, which can be a 16-bit general register or memory word
reg/mem32	32-bit operand, which can be a 32-bit general register or memory doubleword
mem	An 8-, 16-, or 32-bit memory operand

MOV Instruction:

It is used to move data from source operand to destination operand

- Both operands must be the same size.
- Both operands cannot be memory operands.
- CS, EIP, and IP cannot be destination operands.
- An immediate value cannot be moved to a segment register.

Syntax:
MOV destination, source

Here is a list of the general variants of MOV, excluding segment registers:

```
MOV reg,reg
MOV mem,reg
MOV reg,mem
MOV mem,imm
MOV reg,imm
```

Example:
MOV bx, 2
MOV ax, cx

Example:
'A' has ASCII code 65D (01000001B, 41H)

The following MOV instructions stores it in register BX:

MOV bx, 65d
MOV bx, 41h
MOV bx, 01000001b
MOV bx, 'A'
All of the above are equivalent.

Examples:
The following examples demonstrate compatibility between operands used with MOV instruction:

MOV ax, 2	✓
MOV 2, ax	✗
MOV ax, *var*	✓
MOV *var*, ax	✓
MOV *var1*, *var2*	✗
MOV 5, *var*	✗

ADD Instruction

The ADD instruction adds a source operand to a destination operand of the same size. Source is unchanged by the operation, and the sum is stored in the destination operand

Syntax:
ADD dest,source

SUB Instruction

The SUB instruction subtracts a source operand from a destination operand.

Syntax:
SUB dest,source

Sample Program:

```
TITLE Add and Subtract (AddSub.asm)
; This program adds and subtracts 32-bit integers.
INCLUDE Irvine32.inc
.code
main PROC
mov  eax,10000h     ;  EAX  =  10000h
add eax,40000h        ; EAX = 50000h
sub eax,20000h        ; EAX = 30000h

call DumpRegs         ; display registers
exit
main ENDP
END main
```

Lab Exercise:

1. Write an uninitialized data declaration for a16-bit signed integer val1
   Initialize 8-bit signed integer val2 with -10.
2. Declare a 32-bit signed integer val3 and initialize it with the smallest possible negative decimal value.
3. Declare an unsigned 16-bit integer variable named that uses three Initializers
4. Declare a string variable containing the name of your favorite color. Initialize it as a null terminated string. Initialize five 16-bit unsigned integers A, B, C, D & E with the following values: 12, 2, 13, 8, 14.
5. Convert the following high-level instruction into Assembly Language:
   ebx = { (a+b) – (a-b) + c } +d
   a= 10h , b=15h, c=20h, d=30h
6. Convert the given values of a,b,c,d into binary and then use in 8-bit data definition and implement in the equation.
7. Write a program in assembly language that implements following expression:
   Eax = imm8 + data1 – data3 + imm8 + data2

   Use these data definitions:
   Imm8 = 20
   Data1 word 8
   Data2 word 15
   Data3 word 20

Submission Guidelines

1. Submit screenshots of each task containing register values i.e. Debugging window. (in single word file).
2. The codes of all task in a text file. Use Notepad.
3. Submissions should be made on Google Classroom